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Authors
Meylan, Stephan C.

Levy, Roger P.

Bergelson, Elika

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Children's Expressive and Receptive Knowledge of the English Regular Plural

Stephan C. Meylan (smeylan@mit.edu)
Roger P. Levy (rplevy@mit.edu)
Department of Brain and Cognitive Sciences, Massachussets Institute of Techonology

Elika Bergelson (elika.bergelson@duke.edu)
Department of Psychology and Neuroscience, Duke University

Abstract

We investigate the development of children's early grammatical knowledge using the test case of the English regular plural. Previous research points to early generalization, with children applying an abstract morphological rule to produce novel plurals well before 24 months. At the same time, children use the plural inconsistently with familiar object words, and demonstrate limited receptive knowledge of the plural in the absence of supporting linguistic features. In the first study to test knowledge of the plural within participants using a paradigm matched across comprehension and production, we conduct two experiments with n = 52 24-36-month-olds: an eyetracking task to evaluate what they understand, and a storybook task to test how they use the plural. We manipulate both novelty (novel vs. familiar object words) and phonological form (/s/ vs. /z/ plurals). We find strong, age-related evidence of productive knowledge of the plural in an expressive task, but do not find evidence of receptive knowledge in these same children.

Keywords: first language acquisition; linguistic productivity; morphosyntax; linguistic generalization

Introduction

One of the central challenges facing the child language learner is that of inferring the system of compositional rules of their native language, or *morphosyntax* (Rumelhart & McClelland, 1985; Pinker & Prince, 1994). This includes both learning how to use the productive, combinatorial rules of language to communicate with others, and learning what sort of combinations to expect from other speakers. The nature of these nascent representations and their relationship to other levels of linguistic knowledge constitute major open questions in language research.

For English-learning children, the plural – indicating more than one of a countable noun, typically by adding "s" – is one of the most commonly encountered morphemes in the early language environment. Children's usage of plural forms of familiar object words emerges before two years of age in journal studies (Clark & Nikitina, 2009), and is corroborated by parental reports of early vocabulary, with 50% of children using some plural forms of familiar words by 22 months (Frank et al., 2017). Ruling out a pure imitation account, Berko (1958) found that children as young as three can correctly form plurals for novel object words in the well-known "wug" task. This ability has been documented as early as 19 months by subsequent studies (Tomasello & Olguin, 1993).

Despite this early expressive[1] knowledge, English-learning children show protracted development of even the most common regular plurals in their day-to-day speech. Children occasionally use singulars forms for plural referents through age 7 (Berko, 1958); between ages 2 and 4, children often signal plurality in non-adultlike ways (e.g. "two mouse" (Clark & Nikitina, 2009). Moreover, experiments that gauge children's plural *comprehension* have yielded striking failures: children under three struggle without additional cues like grammatical number (Wood et al., 2009; Kouider et al., 2006), and fail with some phonological variants (Davies et al., 2017). Together, these studies suggest that children's linguistic generalizations may differ substantially in content or scope from the grammar of the adult language.

In the current study, we examine early receptive and expressive knowledge of the English regular plural in an attempt to better characterize children's earliest productive morphosyntactic knowledge. In particular, we focus on evaluating the possibility of a time interval in the 3rd year of life (24-36 months) where English learners use the plural in their own speech, but do not reliably use it to understand the speech of adults. The experiments here yield data consistent with such an interval: successes in expressive language concurrent with receptive failures. We relate these results to previous research and discuss the implications of such an expressive/receptive asymmetry for the language learning process.

Background

Previous research suggests that English-learning children may be able to use the plural in their own speech before they can recognize it in fluent speech from others. Kouider et al. (2006) found that children at 24 months failed to look towards plural targets in the absence of additional agreement cues, while children at 36 months succeeded; Wood et al. (2009) found a similar pattern of results in a reaching time task. In contrast to these receptive failures, Tomasello & Olguin (1993), Zapf & Smith (2007), and Ettlinger & Zapf (2011) found that children can often (though not systematically) succeed in expressive tasks, including ones requiring a productive "Add S" rule to form novel plurals.

Taken together, these studies suggest a situation that is the reverse of the default ordering in child language, where receptive knowledge is typically expected to precede expressive language abilities (Clark & Hecht, 1983). But such expressive-first patterns have been observed before in other cases including negation (Nordmeyer & Frank, 2014) and third-person singular verbs (Johnson et al., 2005), among others (Clark & Hecht, 1983). This asymmetry can be explained

[1] We use "expressive" to refer to what children say, and reserve "productive" to refer to compositional language processes (either expressive or receptive).

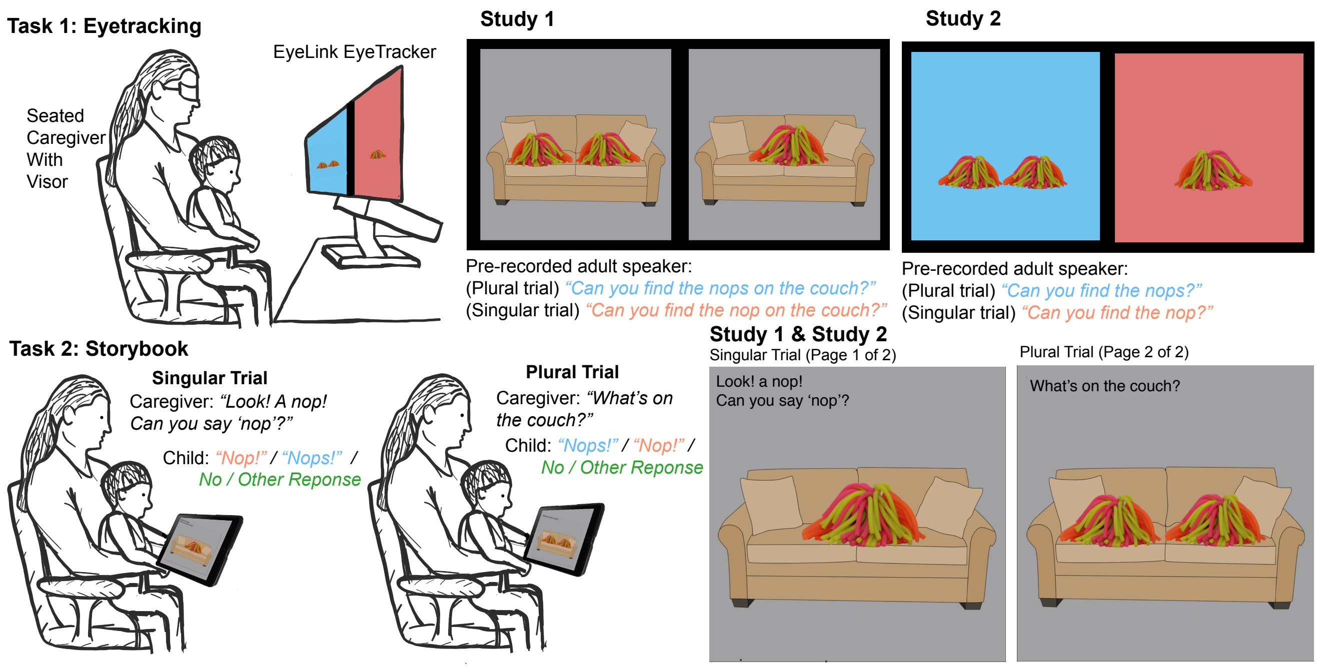

Figure 1: Experimental procedure and sample stimuli for Task 1 (Eyetracking) and Task 2 (Storybook).

by analogy to second language learning: one's ability to say a word in a second language does not necessarily entail the ability to recognize it in the full range of contexts and forms when used by native speakers.

A major consideration is that children at these ages are still developing the ability to identify the relevant phonemic forms; in the case of the plural, +/s/ in *cats*, +/z/ in *dogs*, and +/Iz/ in *buses*. English plurals may be particularly challenging: they appear at the ends of words, in clusters of consonants, and are marked with short, non-salient segments (Sundara et al., 2011). Children may learn some of these forms before others. Davies et al. (2017) investigated 24 month-old children's receptive knowledge of plurals using an eyetracking task that included two novel animate referents (e.g., one *gip* on the left of the screen and several *nops* on the right), and prompted children to look towards the singular or plural referent ("Look at the nops!"). They found that corrected looking time to plural referent was above chance for novel words that used the voiceless form of the plural (/+s/), but not the voiced (+/z/). Further, they show that this pattern contrasts with speech inputs: children hear more voiced plurals (both by type and token count) than unvoiced ones.

The work on children's expressive knowledge (Zapf & Smith, 2007; Tomasello & Olguin, 1993) suggests that an "Add S" rule for forming the plural emerges very early in language development, raising the possibility that such a generalization could support the receptive learning process rather than emerge at its end. For example, a productive "Add-S" rule could help English-learning children extend their knowledge of how the plural is marked. Even if a child could only detect the plural marker in a small subset of cases, an inductive bias to expect the distinction to be marked systematically (i.e., consistent with other parts of the language) could help draw her attention to the relevant sound patterns. On the other hand, this apparent expressive-before-receptive asymmetry could be an artifact of separate experiments testing these abilities in separate samples, or if comprehension tasks are too demanding.

Here we report a study that addresses these concerns by coupling an updated "wug task" (Berko, 1958) that tests children's expressive knowledge of the plural with an eyetracking task that tests their receptive knowledge. To the best of our knowledge, this is the first study to test both expressive and receptive knowledge of the plural within participants using a matched set of stimuli. Both tasks omit extra agreement cues, focusing on children's knowledge of the plural morpheme alone. Given previous work showing wide-ranging abilities over year two, we took a cross-sectional approach across this age range (see Participants).

Methods

Children completed an eyetracking task and a storybook task in a single session (Fig 1). We begin by describing the set of stimuli shared across both tasks. An repository with materials and analysis code is available on OSF.

Shared Stimuli We selected 4 object words in each cell of a $2 \times 2 \times 2$ design crossing novelty (familiar vs. novel), animacy (inanimate vs. animate), and specific form of the plural (/s/ vs. /z/).[2] Familiar items were reportedly used by more than 50% of 24-month-olds on the MacArthur Bates Communicative Development Inventory-Words & Sentences (CDI), as determined via Wordbank (Frank et al., 2017).

Images of inanimate novel objects were taken from a novel object database (Horst & Hout, 2016); animate novel objects were derived from these. For counterbalancing, we selected two 16-item sets from the 32 total stimuli. The sets

[2] We omitted /Iz/ plurals (e.g. *buses*) and irregulars (e.g. *mice*) as these are less frequent and learned later (Berko, 1958).

were matched for frequency of familiar nouns in CHILDES (MacWhinney, 2000). Each child was randomly assigned to one set for eyetracking, and the other for the storybook (i.e., they saw different stimuli in the two tasks).

Eyetracking Stimuli There were two versions of our eyetracking task, Study 1 and 2. In both, singular and plural panels depicting the same item were presented side-by-side (Fig. 1, top). Pre-recorded auditory prompts directed infants to look at one of the panels in non-consecutive trials (e.g., "can you find the cat" or "can you find the cats?"). The target referent appeared once on the left and once on the right. The singular object was set to 75% of the combined (pixel) area of the plural objects to mitigate potential saliency effects; see Fig.1. Audio stimuli were recorded in a soundproof booth by an adult male speaker in child-directed speech.

Study 1 In Study 1, the spoken prompt included a prepositional phrase identifying the location of the target referent, X, e.g., "{*do you see the / can you find the* } X {*in the tree*, *on the couch*, *in the house*, *on the hill*}?" Both singular and plural items and the location (hill, etc.) occurred on a plain gray background (Fig. 1). Definite reference to location (*couch*, *tree*, *house*, *hill*) allowed us to clearly differentiate the singular and plural target sentences, i.e. "nops on the couch" does not readily refer to all three nops onscreen, but rather to the half of the display with two nops on one couch. Prepositional phrases were all vowel-initial, to highlight the voicing contrast, which might otherwise be devoiced in sentence-final contexts (Smith, 1997).

Study 2 In Study 2 we made two key simplifications. First, we omitted the prepositional phrase, e.g., "{*do you see the / can you find the*} X?". Second, while the side that the singular and plural panels occurred on remained counterbalanced across trials and items, the left panel was always light blue, and the right panel always red (Fig. 1). These changes aimed to address the possibility that the location word in Study 1 increased task demands.

Eyetracking Procedure Receptive knowledge was assessed using the "Looking While Listening" paradigm (Fernald et al., 2008). Eye movements were recorded at 500 Hz with an SR Research Eyelink 1000+. Children sat in caregivers' laps, 55 - 65 cm from a 43 cm diagonal monitor. The eyetracking task began with 5-point calibration, followed by four practice trials where the child was asked to find a singular familiar object. Then, on each 10s trial, the child saw the two panels for 2500 ms before each utterance began.

Raw tracks were converted to fixations in R 3.5.1 (R Core Team, 2017), converted to 20 ms bins, and classified as a look to the target, distractor, or neither. Following Bergelson & Swingley (2015), individual trials were excluded if a child looked at a single panel for the duration of the trial, or if a child looked offscreen for more than 66% of the interval of interest (13% of all trials). Children were excluded for fussiness before the application of the data-driven filter described above (see Participants). Any child with 50% trial loss or higher would have been excluded, but no children met this criterion.

Following (Davies et al., 2017), we analyzed the proportion of target looking from 367 to 4000 ms after disambiguation. The disambiguation point for all trials was the earliest time it was clear whether the noun was singular or plural: for plurals, this is the onset of the plural market (see 0 ms in Fig. 2)); in singular trials this was just after the offset of the noun. Fixations from 0 - 367 ms reflect planning before encountering the disambiguating material, and are thus grouped with the preceding interval (Swingley & Aslin, 2000). To confirm that the eyetracking task and analysis approach worked as expected for adult participants, we ran 9 and 15 adult pilot subjects in Studies 1 and 2, respectively.

Storybook / Expressive Task Upon completion of the eyetracking task, the caregiver read a storybook from an iPad designed to elicit both singular and plural responses for 16 object words (which were not the same items in the eyetracking task). The storybook consisted of four single-page practice trials as in the eyetracking study, and sixteen singular/plural test trial sequences. The first page of each test sequence displayed a single object presented on one of the four locations described above (e.g. on the couch), and the caregiver read a corresponding written prompt, e.g. "Look, a cat! Can you say cat?" For these singular trials, caregivers were instructed to elaborate in whatever way they would typically during storytime to elicit a response from their child, e.g. "Grandma has a cat just like this one, doesn't she? Can you say cat?" On the second page of each sequence, two objects identical to the previous were placed in the same background, and caregivers read a prompt "What's *on the couch / in the tree / in the house / on the hill*?". On these plural trials caregivers were instructed to only repeat the exact written phrase so as to avoid additional linguistic cues for a plural or singular response. Caregivers were asked to refrain from pointing because of the inherent difficulty in pointing to a plural referent without pointing to its individual components. For both singular and plural trials, caregivers were instructed to wait 10-15s to see if their child would produce a response, and were instructed to provide non-specific positive feedback after all trials.

The spoken productions of child and caregiver were recorded with a microphone for offline coding. Productions on both trials were coded into one of four categories: 1) No Response / Not Relevant (silence, babble, responses like "on the couch!") 2) Singular ("nop") 3) Non-Conventional Plural ("two nop" or "nop nop") or 4), Plural ("nops" or "two nops"). All trials from 25 randomly selected children were recoded by a hypothesis-blind second coder, Cohen's κ = 0.87 for singulars, 0.8 for plurals.

Participants Participants (before exclusions) were 53 toddlers in the age range 23.5 - 36.5 months. (M = 30.17 months, 29 female). This age-range was chosen because of the reported asymmetry between expressive and receptive knowledge reported over this period (Davies et al., 2017; Zapf & Smith, 2007). Exclusions were tracked separately for the eyetracking and storybook tasks; age distribution of the fi-

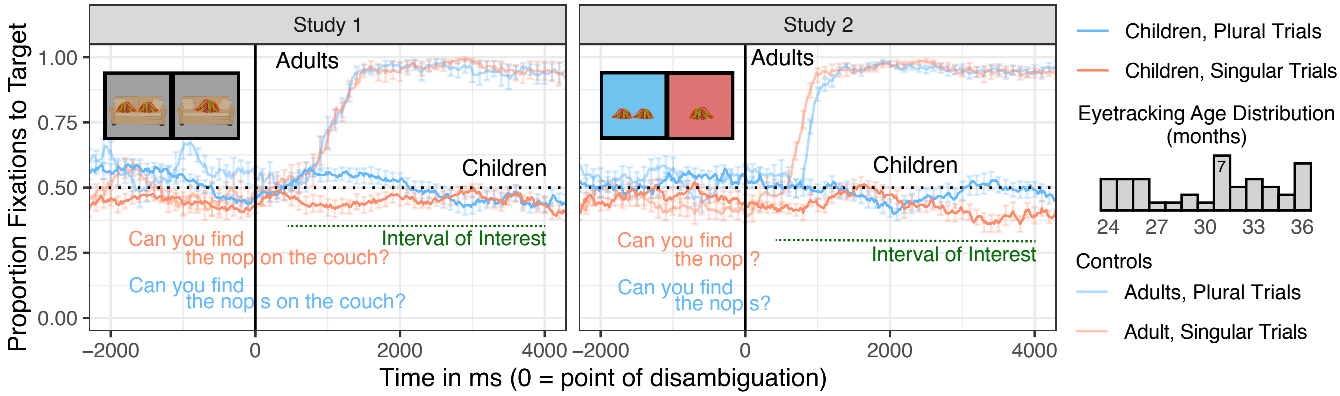

Figure 2: Eyetracking timecourses for Studies 1 and 2. Lines and and errorbars correspond to mean and standard error of the mean over participants. Trials are aligned so that 0 ms is the beginning of the disambiguating segment.

nal samples are show in Fig. 2 (eyetracking) Fig. 6 (storybook). 52 children in total contributed data. 24 children were run in Study 1; 4 were excluded from eyetracking (all for fussiness) and 2 from the storybook task (1 for fussiness, 1 for recording error). 29 children were run in Study 2; one was excluded from both tasks (for fussiness), 6 were excluded from the eyetracking task (3 for fussiness, 3 for eyetracking problems), and one from the storybook task (for fussiness). 12 storybook trials across 8 children were discarded due to sound quality or overlap with parents' speech.

Results

As described above, previous research suggests that children may pass through an interval between 24 and 36 months where they use the plural in their own speech but fail to use it to identify referents in fluent speech from adults. If this is indeed the case, we expect children who say many plurals in the expressive task to fail to look to referents corresponding to singular and plural prompts in the receptive task. We begin by describing the results of each task alone, then describe analyses relating performance across tasks.

Eyetracking Task: Analysis of Looking Times

While adults look at a singular or plural referent corresponding with a prompt, the children in our sample do not (Fig. 2). For statistical testing, comprehension was operationalized as *Increase in Target Looking*, or the proportion of target looking after disambiguation minus the proportion in the preceding interval (trial start to disambiguation). This approach accounts for children's baseline preferences, e.g., a general preference to look at the panel with more instances of an object.[3]

10 of 20 children in Study 1 and 12 of 22 in Study 2 demonstrated a numerical increase in target looking. In both studies, subject means were near zero (Study 1: M = 0.004, SD = 0.06, range = -0.14- 0.08; Study 2: M = -0.005, SD = 0.08, range = -0.18- 0.15); after confirming that Increase in Target Looking was normally distributed in both studies (Shapiro-Wilk normality test, $p > .1$ in both cases), one-sample t-tests reveal that neither is different from chance (Study 1: $t(19)$ = 0.31, p = 0.76; Study 2: $t(21)$ = -0.28, p = 0.78).

To evaluate the effects of the three item manipulations (familiarity, voicing, animacy), we constructed Bayesian linear mixed effects models for each study with `brms` 2.11.1 (Bürkner, 2017). We take increase in target looking as the response variable and use the maximal random effects structure (Barr et al., 2013) with respect to these manipulations of interest: $increase\_in\_target\_looking \sim novelty \times voicing \times animacy \times target * child\_age + trial\_order + (novelty \times voicing \times animacy \times target|participant) + (target \times child\_age|item)$. Consistent with the overall null effect above, the 95% CIs for the intercepts of both studies cross 0; further, performance did not vary as a function of our three item manipulations in either study (Fig. 3). This includes a null effect for the phonetic form of the plural (Study 1: β = 0.019, 95% CI = -0.063 - 0.103; Study 2: β = 0.016, 95% CI = -0.056 - 0.089), contrary to Davies et al. (2017).

Given that all children did the same storybook task, that toddlers were at chance in both versions of our eyetracking task, and that there was not a significant difference in looking times between Studies 1 and 2 (Welch two-sample t test, $t(38.3)$ = 0.41, p = 0.68) we collapsed the two eyetracking studies to boost analytic power for our subsequent analyses.

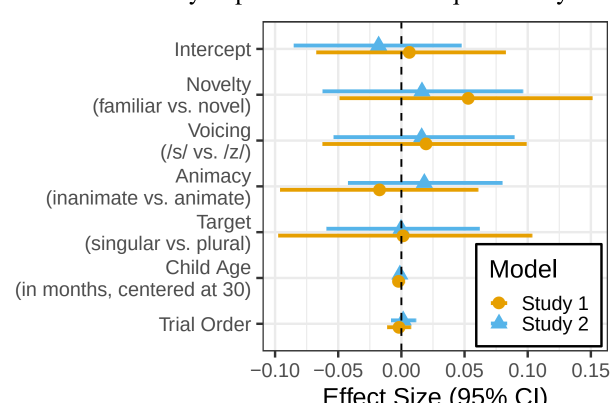

Figure 3: Fixed effects for linear mixed effects models predicting Increase in Target Looking (before vs. after disambiguation) in Studies 1 and 2. Children do not look to the named (singular/plural) target significantly more than chance.

[3] Baseline correction, difference scores (Bergelson & Swingley, 2012), and raw proportion looking time all yielded qualitatively similar results. Using baseline correction allows us to use trial type as a predictor for the mixed effects models, which cannot be done with the difference scores.

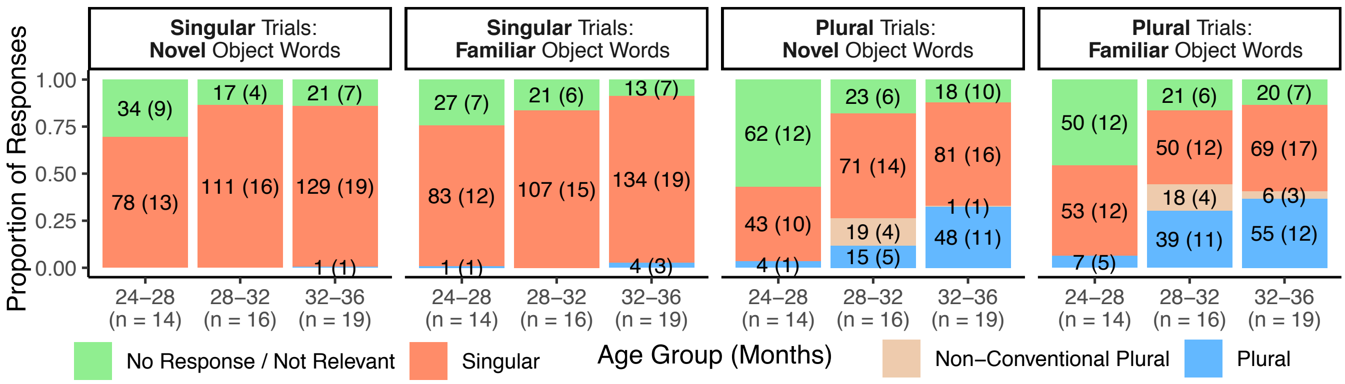

Figure 4: Proportion of children's responses on the storybook task falling into four categories, indicating an increasing ability to use the plural, but with novel plurals from the earliest age interval. Category labels indicate *# of responses* (*# of children*).

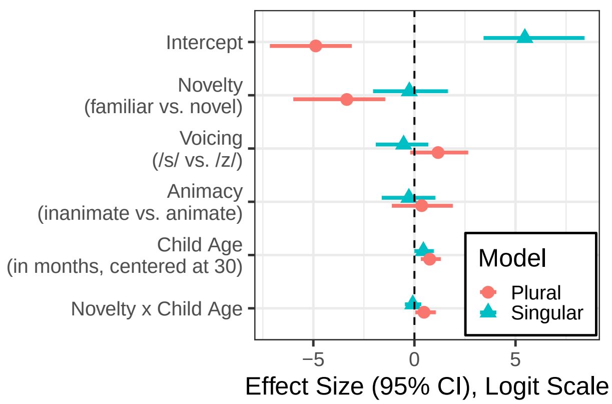

Figure 5: Main effects and significant interactions from a logistic mixed effects models predicting storybook responses.

Storybook Task: Analysis of Plural Usage

The primary measure of children's expressive of the plural was operationalized as the proportion of trials where they supplied the singular that they also supplied the plural. Proportion of plural productions by child were not normally distributed in either study (Shapiro-Wilk normality test, both ps $< .005$), with a substantial number of children producing few or no plurals (Fig. 6B). The proportion of plural productions by child were not distinguished between Studies 1 and 2 (Wilcoxon rank sum test, W = 234.5, p = 0.4); we thus collapsed across studies for further analysis.

The proportion of responses by category in three age groups is shown in Fig. 4. Descriptively, we find: 1) a decreasing proportion of non-responses with age, 2) a small number of plural responses on singular trials, 3) a peak in non-conventional plurals around 30 months, 4) increasing usage of the plural with age (higher for familiar than novel object words) and 5) at least some novel plurals in every age interval, including the earliest.

To parse apart the effects of voicing, novelty, and animacy on responses to singular and plural trials we constructed two mixed-effects logistic regression models predicting success on singular trials (Model 1) and success on plural trials (Model 2). We kept these models separate because Model 2 just included those plural trials immediately following singular trials where children successfully provided a singular response. Model 2 thus excludes trials where children fail to produce the plural because of shyness, fussiness, or lack of interest in the task. We fit the models with the results from 832 singular trials and 689 trials, respectively. We used a maximal random effects structure, $expressive\_success \sim novelty \times voicing \times animacy \times child\_age + (novelty \times voicing \times animacy|child) + (child\_age|item)$. The results of the two models are shown in Fig. 5.

The intercept estimates show that children were well above chance in providing the singular (which they just heard their parent say), and well below chance in providing the plural (for which they had to generate the plural for the singular they just heard, and potentially said). Older children produced more responses in both the singular and plural trials. While children were equally likely to respond with novel and familiar singulars on singular trials (no effect of novelty, β = -0.271, 95% CI = -1.864 - 1.47), children were less likely to respond with the plural form for novel object words than for familiar object words (β = -3.216, 95% CI = -5.706 - -1.402). A novelty $\times$ child age interaction was significant in the plural model (β = 0.449, 95% CI = 0.059 - 0.938) suggesting that the odds that children would produce novel plurals increased by a factor of 3.85 for each month after 30 months.

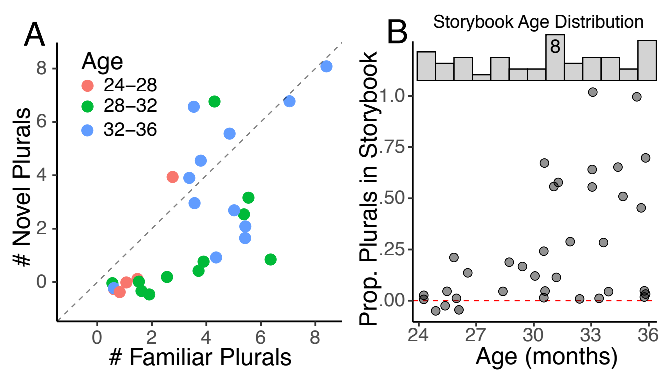

Figure 6: **A.** Number of familiar vs. novel plurals provided by children who provided at least one of either (28 of 49). Children produce familiar plurals before novel ones, though they do not master familiar forms before generalizing. **B.** Proportion of plurals produced on storybook trials following successful singular productions increases with age, though many children do not produce plurals. The marginal histogram shows the number of storybook participants by age.

To examine the relationship between children's use of novel and familiar plurals, we examined the correlation between the number of responses in each category (Fig. 6A). Whereas item-based theories (e.g., Abbot-Smith & Tomasello, 2006) predict that children should respond with novel plurals only *after* mastering a substantial number of familiar ones, we find instead that performance on novel plurals and familiar pluralls is strongly correlated (Spearman's ρ = 0.716; 95% bootstrapped CI = 0.44 - 0.871, $p < .001$). This suggests that children may use a productive rule to generate novel plurals even as they continue to use singular forms for many familiar object words.

Expressive Knowledge, Receptive Knowledge, and Age
Finally, we investigate the relationships between expressive knowledge of the plural, receptive knowledge, and age. We do not find a statistically significant correlation between the receptive and expressive knowledge as measured by these two tasks (Spearman's ρ = -0.193, bootstrapped 95% CI = -0.476 - 0.123, p = 0.254). (Figure 7) While expressive knowledge is correlated with age (Spearman's ρ = 0.468, CI = 0.144 - 0.723, p = 0.003), receptive knowledge is not (Spearman's ρ = -0.087, CI = -0.374 -0.22, p = 0.585).

Discussion

In the current study, we examined children's receptive and expressive knowledge of the English regular plural, both for novel and familiar object words and across two different phonological forms (+/s/ and +/z/). Using an eyetracking task, we do not find evidence of adult-like receptive knowledge of the plural between 24 and 36 months. In contrast, we find that many of these same children can use the plural in their own speech, even forming plurals for wholly novel object words.We now consider these results in relation to possible confounds and compare them to the results obtained by previous research.

Receptive Knowledge Davies et al. (2017) found that children looked to novel voiceless (+/s/) plurals above chance in a similar experiment, while we find no effect of voicing. This may be due to item differences across studies, though we note Ettlinger & Zapf (2011) also fail to find a voicing effect.

More generally, children may not exhibit receptive knowledge of the plural for several reasons, even if they have fully adult-like knowledge of the linguistic distinction. First, receptive failures could emerge from the high task demands, including the inclusion of novel words (both Studies 1 and 2) and the presentation of referents in complex scenes (Study 1). Second, children may have construed all three items onscreen as a possible referent (i.e. with "nops" referring to *all* referents on the display). While we took several precautions against this construal—the referents are visually separated in both studies; either by location (Study 1) or panel color (Study 2)—it may still have occurred. If, on the other hand, children's eyetracking task performance reflects genuine limitations in linguistic knowledge rather than task demands, we should expect children to look towards the appropriate referents when provided with additional cues regarding

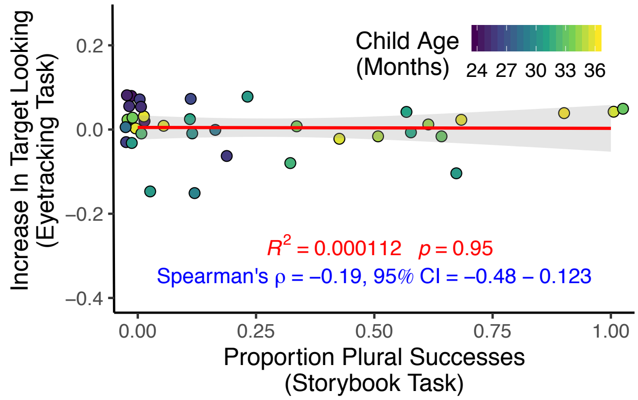

Figure 7: Performance on the storybook task (x-axis) vs. performance on the eyetracking task (y-axis) across children does not show a statistically significant correlation.

the appropriate referent, such as a copular verb that agrees in number and/or a numeric quantifier. In ongoing work, we are testing children in a third condition that uses both quantifier and copular verb cues to number, e.g., "Where *are* the *two* nops?" If children are able to succeed in this receptive task with additional cues to number, it would point to limitations in the interpretation of plurals marked by morphology alone rather a preference to treat all items onscreen as a referent.

Expressive Knowledge In the case of expressive knowledge, we found a qualitatively similar pattern of results to Zapf & Smith (2007), with children supplying more familiar than novel plurals. Ettlinger & Zapf (2011) found higher levels of plural responses for familiar object words for English-learning 22-35-month-olds than we find here (52% correct plurals, vs. 24% in the current study). We speculate that their higher performance may be attributable to task structure. They used a puppet act-out task where children had to complete the experimenter's request to a puppet to pick up a familiar singular or plural object word, e.g., "Can you tell Teddy to get [*points to object*]?"Based on the puppet's actions, children got visible feedback for what they said, which may push them to consider other strategies. In contrast, children in our task did not receive any feedback. It may also be the case that asking for a common concrete object word is a more familiar — and thus easier—task for two-year-olds than describing a scene ("what's on the couch?"). Further research is needed to explore these possibilities.

Conclusion

We used an eyetracking task coupled with a storybook task to assess receptive and expressive knowledge of the plural within the same children. Like Zapf & Smith (2007), we found evidence for productive knowledge of the plural in expressive tasks among children between 24 and 36 months. In that same population, we found no evidence of receptive knowledge as manifested in eye-tracking data during passive listening. Children supplied familiar plurals before novel ones, though they do not master familiar plurals before starting to use a productive "Add -S" rule in an expressive task. Our data will support future work on the timeline and dynamics of children's morphosyntactic generalizations.

Acknowledgements

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