

Children infer speaker groups from variation in morphosyntactic patterns

Yiran Chen^{1*}, Lynna Tran², and Jenny Saffran¹

¹Waisman Center, University of Wisconsin—Madison, Madison, United States

²Department of Psychology, Princeton University, Princeton, United States

*Corresponding author: Waisman Center, University of Wisconsin—Madison, 1500 Highland Ave, Rm 535, Madison, WI 53705, United States. Email: chen2537@wisc.edu

Abstract

Variation in how people use language provides powerful cues to social identity. As children join a language community, they must acquire such sociolinguistic knowledge. Prior work shows that children link broad language varieties to social groups, but little is known about whether they can use variation in specific language features to infer speakers' group membership. 40 English-speaking children aged 5–6 years ($M = 72.2$ months; $N_{\text{female}} = 22$, $N_{\text{male}} = 18$; $N_{\text{White}} = 35$, $N_{\text{Asian,White}} = 3$, $N_{\text{Black,White}} = 1$; $N_{\text{other}} = 1$; all non-Hispanic) participated between October 2024 and August 2025 in a semi-artificial language learning study in which they were exposed to 2 alien groups that differed in plural marking. Children were then tested on their ability to determine which group new aliens belong to based solely on their plural usage. Children succeeded when the group-marker mappings were deterministic, but not when they were probabilistic. These findings suggest that young children use consistent morphosyntactic patterns to infer group membership and highlight a novel approach to studying sociolinguistic learning. Future research will extend this paradigm to include more realistic social categories that are meaningful to children.

Keywords group membership, linguistic variation, artificial language learning, sociolinguistics

Lay summary

As children grow up, they learn not only what words mean but also who speaks in certain ways, which helps them identify groups. We asked whether children can use grammar, beyond accent, to infer group membership. We invited 5- to 6-year-old children to play a “space language” game with two alien groups that used the same animal words but different plural endings. In one condition, each group always used its own ending; in another, each mostly did (75%) but sometimes used the other's. Later, children decided which group new aliens belonged to using only plural marking. Children succeeded with consistent patterns but struggled with unreliable ones, suggesting that by age five, they can learn stable group-linguistic form mappings.

Language is a powerful tool for perceiving and constructing social identity. Across cultures, *how* people speak, not just what they say, shapes perceptions of who they are and how they relate to others. Adult listeners routinely make inferences about a speaker's gender, age, regional background, and membership in social or cultural groups based on linguistic cues (Babel & Munson, 2014; Giles & Billings, 2004; Glusek & Dovidio, 2010; Labov, 1986, 2001, 2006; Porter et al., 2016). Adults also make inferences about subjective traits such as competence, attractiveness, and integrity (Campbell-Kibler, 2007, 2010; Lambert et al., 1960). As such, language can not only signal social affiliation but also serve as a basis for exclusion. Individuals may face social penalties, such as discrimination in legal, professional, and economic contexts, based on how they speak (Hansen & Dovidio, 2016; Purnell et al., 1999).

The social meanings that listeners extract from speech are not limited to broad, global features such as the language that speakers use (e.g., French), the dialect they speak (e.g., African American English), or their accent (e.g., English spoken with a Chinese accent). More fine-grained linguistic cues, such as the pronunciation of a single sound, the choice of a particular word, or the use of a specific grammatical form, can also carry powerful social information. For instance, using “pop,” “soda,” or “coke” as the generic name for sweet carbonated soft drinks provides clues about the speaker's regional identity. American English speakers who frequently produce -in' endings (e.g., walkin') instead of -ing (e.g., walking) are judged as less educated (Campbell-Kibler, 2007). These findings highlight the fine-grained nature of sociolinguistic perception.

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Children must navigate this complex landscape as they learn to speak and understand their native language(s). To become competent members of their communities, children must not only acquire linguistic forms but also understand the social meanings that these forms can carry. However, the development of this aspect of sociolinguistic competence remains underexplored. A substantial body of work has documented that young children can distinguish speakers who use a familiar language or accent from those who don't. Infants and preschoolers favor native-language speakers in social and learning contexts (Kinzler et al., 2007, 2009, 2011, 2012; Souza et al., 2013), selectively attending to, trusting, and affiliating with them (Begus et al., 2016; Buttelmann et al., 2013; Marno et al., 2016; Shutts et al., 2009). Children also infer that speakers of unfamiliar languages or accents belong to different social groups from themselves (Hirschfeld & Gelman, 1997). Children use language to infer third-party social relationships: preschoolers expect individuals who speak the same language to be from the same place (Weatherhead et al., 2016), and even 9-month-olds expect same-language speakers to affiliate with one another (Liberman et al., 2017).

However, far less is known about whether children can map variation in a specific linguistic feature onto social categories. Research on this topic has primarily focused on children's ability to categorize people based on their accents. For example, 5- to 6-year-olds can distinguish speakers with foreign accents from those who share their home dialect, but they struggle to differentiate regional dialects of their native language (Girard et al., 2008; Wagner et al., 2014). By age seven, children in the UK begin to show sensitivity to regional accent differences (Flocchia et al., 2009). Accent-based categorization, however, may rely on a broad array of phonetic, prosodic, and intonational cues, leaving the granularity of children's sociolinguistic perception uncertain. Evidence from register perception similarly shows that 4- to 5-year-olds can distinguish formal from casual speech styles and use them to infer who a speaker is addressing (Wagner et al., 2010). Moreover, while these studies highlight emerging abilities in the phonological domain, the morphosyntactic domain remains virtually unexplored. Importantly, whereas accent-based categorization often relies on deterministic cues (e.g., a British speaker with a received pronunciation accent always pronounces *spat* with [a]), many socially meaningful forms are probabilistically associated with social categories (e.g., the frequency of *-in'* vs. *-ing* in American English). Whether children can track such probabilistic associations and use them to draw inferences about speakers' social category membership remains unknown. Morphosyntactic variation provides a powerful test case for addressing this question.

In parallel, research that engages with the acquisition of specific linguistic variation has focused primarily on children's production rather than their understanding of the social cues carried by linguistic variation. Developmental sociolinguistic studies demonstrate that even young children mirror adult-like sociolinguistic patterns in their speech (Chen & Schuler, 2025; Chevrot et al., 2011; Labov, 1989; Miller, 2013; Nardy et al., 2013; Roberts, 2002; Shin, 2016; Smith et al., 2007, 2013). For instance, just as adult female speakers tend to use more standard forms than male speakers, girls often produce more standard forms than boys (e.g., *walking* vs. *walkin'*) (Fischer, 1958). However, most of these findings are based on naturalistic production data, making it difficult to determine whether these production patterns reflect true

social knowledge or differences in caregiver input. For example, it's hard to disentangle whether girls produce more standard forms than boys because they identify and align with the social group whom they observe using more standard forms (i.e., adult female speakers), or because caregivers use standard forms more frequently to girls than boys (Foulkes et al., 2005). Experimental approaches are therefore crucial for directly testing the kinds of inferences children can draw about linguistic variation.

One experimental approach employs artificial language learning paradigms designed to mimic real-life sociolinguistic variation. In these studies, children are taught a miniature artificial language with novel words and grammatical patterns, and their productions are compared to the input. Findings suggest that consistency, whether linguistically conditioned (e.g., a determiner's appearance depended on whether a noun is in subject or object position; Kam, 2015) or speaker-conditioned (e.g., two speakers had systematic but different patterns of determiner use; Samara et al., 2017), helps children retain variability from the input and reduces their tendency to regularize by collapsing inconsistent forms. Particularly relevant here, Samara et al. (2017) found evidence of learning only when the speaker-determiner association was deterministic—such that one speaker always used one determiner while the other consistently used a different one—but not when the association was probabilistic, underscoring the challenge of learning probabilistic conditioning. While this work has provided important insight into how children learn and reproduce variation, it has primarily examined language learning outcomes. What remains unknown is whether children can also interpret such variation as socially meaningful and use it to draw inferences about the speakers themselves (e.g., which speaker is most likely to have produced a given utterance).

To bridge these gaps, the current study was designed to ask whether children can use grammatical variation to make inferences about who is speaking. To do so, we exposed children to a novel set of speakers—two visually distinct groups of aliens. Each group of aliens produced a novel instantiation of a familiar morphosyntactic feature—plural morphology. After exposure, children heard sets of plural nouns and had to guess which alien had produced them. The question of interest was whether children had learned the connection between the two forms of plurals and speaker group membership.

We chose to manipulate plural morphology for several reasons. First, plural forms are learned early by English-acquiring children, who reliably produce plural forms by around age three (Kouider et al., 2006). And, importantly, plurality is easy to depict in images. In our paradigm, children were first exposed to a semi-artificial language spoken by two visually distinct alien groups who differed in how they marked plural nouns. The association between plural form and group membership was manipulated between subjects to be either deterministic—each group exclusively used a distinct plural marker—or probabilistic—each group predominantly used one marker but occasionally used the other group's marker. During the test, children heard plural descriptions from novel, unseen speakers, whose plural marking pattern aligned with one of the two alien groups. Children's task was to categorize these speakers based solely on their plural marking patterns. Using an artificial language and novel speaker groups (aliens) allowed us to examine children's ability to map linguistic forms to groups of speakers in the absence of prior experience with either

the forms or the groups. The study was preregistered on OSF (links here: <https://osf.io/zat3b> [deterministic condition] and <https://osf.io/t2qkv> [probabilistic condition]).

Method

Participants

Forty 5- to 6-year-olds ($M_{\text{age}} = 72.2$ months; $N_{\text{female}} = 22$) participated between October 2024 and August 2025 in the study. The preregistered sample size was determined via an a priori power analysis informed by pilot data. A pilot study in the deterministic condition ($N = 12$) indicated that a sample of 14 children would provide 95% power to detect above-chance categorization in a one-sample *t*-test ($d = 1.05$). Given the potential instability of effect size estimates from small pilot samples, we increased the target sample to 20 children and enrolled the same number in the Probabilistic Condition to ensure balanced samples across conditions. We focused on this age range because plural morphology is reliably acquired by age 4 for English-learning children (Kouider et al., 2006), providing a foundation for testing whether children can use variation in plural marking to support social inferences. This age range has been used successfully in prior artificial language learning studies requiring children to track distributional patterns of grammatical markers (Austin et al., 2022; Kam, 2015; Samara et al., 2017), suggesting that the task demands of the current study would be manageable for our participants. Half of the sample was assigned to the Deterministic condition and half to the Probabilistic condition. The two conditions didn't differ in age ($M_{\text{Det}} = 72.3$, $M_{\text{Prob}} = 72.2$) or gender distribution ($N_{\text{female}} = 11$ in both conditions). According to the parent report, all of the children were monolingual native English speakers with less than 25% exposure to a second language, no vision or hearing loss, and no known developmental diagnosis. Twenty-eight additional participants were excluded from the final data sample for failing to meet preregistered criteria: 2 fussed out, 5 made exclusively one-sided test selections, 2 did not reliably learn that the novel markers were plural markers (did not reach 80% accuracy on picture-selection in the second half of exposure), and 19 failed the required number of attention checks.¹ Participants were predominantly White ($N_{\text{White}} = 35$; $N_{\text{Asian, White}} = 3$, $N_{\text{Black, White}} = 1$; $N_{\text{other}} = 1$), and none identified as Hispanic. Participants were recruited in a midwestern city using an existing database of interested families. Written informed consent was obtained from all parents and verbal assent was obtained from the child participant prior to experiment participation, and experimental protocols were all approved by the local IRB.

Materials

Participants were exposed to two alien groups: green slender Gulus and red muscular Norls. The images were adapted from a stimulus set previously used to depict two novel groups (Lai et al., 2020). Participants saw a total of eight different exemplars of Gulus and eight different exemplars of Norls, two pairs during exposure and six pairs during the test (see Figure S1). All speech stimuli were generated using a text-to-speech synthesizer (NaturalReader). During the exposure phase, each alien spoke

with a different female voice. A new female voice was used during the test phase.

During the exposure phase, the aliens described pictures of animals using noun phrases from a semi-artificial language. The language consisted of four English nouns (chicken, sheep, pig, duck) and two artificial plural markers (*ka* and *po*). Utterances in the language were formed NOUN when singular and NOUN MARKER when plural. Singular images always had one animal. Plural images displayed during the exposure phase included either two or four animals, and plural images displayed during the test phase included either three or five animals. The numbers were varied to help our participants generalize the plural-marking rule beyond specific quantities.

We created two between-subjects conditions based on the distribution of plural markers between the two alien groups. In the Deterministic condition, Gulus always used the *ka* plural marker, and Norls always used the *po* plural marker. In the Probabilistic condition, Gulus used the *ka* plural marker 75% of the time and the *po* plural marker 25% of the time, while Norls used the *po* plural marker 75% of the time and the *ka* plural marker 25% of the time. The Deterministic condition was designed to provide a maximally predictable structure, while the Probabilistic condition was included to determine whether children can exploit less predictable associations.

Procedure

Participants played an interactive iPad game that included an introductory phase, an exposure phase, and a test phase. Children were first introduced to members of the two alien groups. During this phase, children were told that the green aliens were Gulus and the red aliens were Norls. To help further differentiate between the two groups beyond their distinct physical appearances, they were also told that Gulus like ice cream and Norls like cheese. The linguistic differences between the two groups were not mentioned.

The exposure phase included 48 trials evenly distributed among four blocks. On each trial, children viewed a pair of images and heard an utterance from one alien (see Figure 1A and B). The image pairs included either one singular and one plural image of the same animal (e.g., 1 pig and 2 pigs) or two singular pictures depicting different animals (e.g., a pig and a duck). The alien's utterance on a given trial either contained just the matching noun in singular form ("pig") or a noun with a novel plural marker ("pig ka"). To highlight the plural markers, 32 trials presented a singular image alongside a plural image of the same animal. The remaining 16 trials paired singular images of two different animals, confirming that both alien groups used the same nouns. Each of the four animals served as the target on an equal number of trials. On each trial, either a Gulu or a Norl appeared, with Gulus always appearing on the left and Norls always appearing on the right. After hearing the spoken utterance, the participant would touch the image that matched the alien's description from the two options and receive immediate feedback. Participants could only move on to the next exposure trial after they made the correct selection.

To reinforce attention to the speakers, children also completed eight 1-back speaker-attention checks evenly distributed throughout the exposure phase, where they were presented with the two aliens and asked who just spoke on the last trial (e.g., "Who just

¹ Exploratory analyses performed with less conservative exclusion parameters are provided in the Results section.

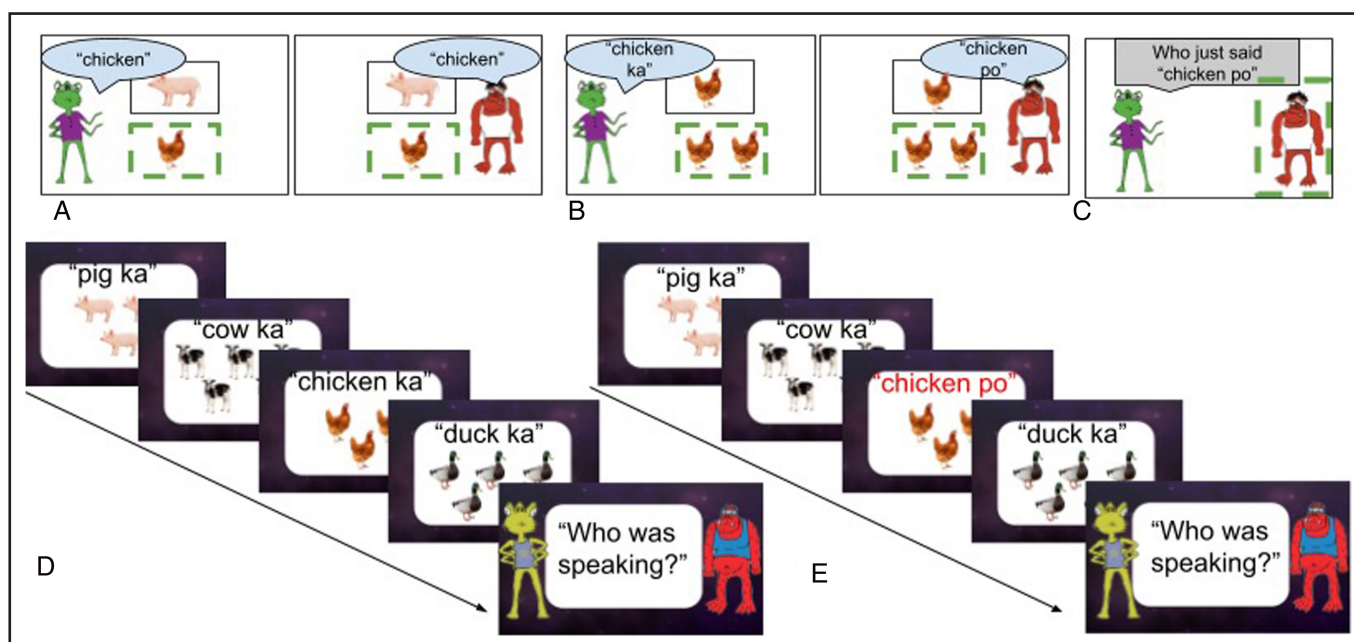


Figure 1 Sample trials illustrating exposure and test trials. Note: Sample trials illustrating (A) singular exposure, (B) plural exposure, (C) 1-back attention check, (D) deterministic test, and (E) probabilistic test. Texts are only for illustration purposes; all language input was auditory. Dashed-line frames in exposure trials indicate feedback upon correct choice. The serial position of the minority-marker trial (labeled "chicken po") during probabilistic test is counterbalanced.

said chicken ka?" and they were prompted to touch the picture of either the Gulu or the Norl). The accuracy of these checks constituted one of the exclusion criteria. Eight 2-AFC food preference trials were also interspersed throughout the exposure phase (i.e., they were asked either "What does a Gulu like to eat?" or "What does a Norl like to eat?") to probe understanding as well as reinforce the distinction between the two groups.

The test phase consisted of 12 categorization trials. On each trial, children heard a different novel female voice describe four plural images of animals. Each image was presented in the center of the screen, one at a time. The four utterances on each trial reflected one alien group's distributional pattern during exposure (Figure 1c and d): In the Deterministic condition, all four utterances used either *ka* or *po* exclusively. In the Probabilistic condition, three utterances used one marker, and one used the other (75%/25%), with the position of the minority marker counterbalanced across trials. After each set of utterances, children were asked to indicate whether the speaker was a Gulu or a Norl. Half of the test trials featured trained animals from the exposure phase, and the other half featured new animals (cat, dog, cow, and horse) to assess generalization. Test trials were presented in a pseudo-randomized order.

Data were analyzed in R (R Core Team, 2020) via Google Colab, a cloud-based Jupyter notebook (Kluyver et al., 2016). Figure creation and data wrangling were accomplished with the tidyverse (Wickham et al. 2019). Mixed-effects regression models were fitted with the lme4 package (Bates et al., 2015).

To determine whether children used deterministic and probabilistic linguistic differences to infer social category membership on the test trials, we built three logistic mixed-effect models. In the first model, we compared children's ability to infer social group membership in the deterministic and probabilistic conditions. Each test response was coded as correct (1) or incorrect (0).

In the probabilistic condition, a response was considered correct if the child selected the alien group that was more likely to produce the observed marker (i.e., Gulu for *ka*-dominant sequences, Norl for *po*-dominant sequences). The first logistic mixed-effects model predicts whether children chose the correct alien (0 vs. 1) with fixed effects of condition (deterministic vs. probabilistic, sum coded), child age (z-scored), and with by-subject random intercepts. If children are able to use speakers' grammatical patterns to infer group membership, we expect a significant positive intercept, which means that they are more likely than not to be correct. If children are more likely to do so when presented with deterministic associations between language pattern and social category, we will observe a main effect of condition. Lastly, if children show developmental change in this age range, we should observe a significant main effect of age.

We built two additional models for each of the two conditions to analyze the performance in each respective condition. In each model, we predicted response correctness (0 vs. 1) with fixed effects of Child age (z-scored), noun type (trained vs. new animal nouns, sum coded), and their interaction. Random effects included by-subject random intercepts and by-subject random slopes of noun type. All analyses were preregistered.

Results

Children were highly accurate during exposure trials, reliably selecting the plural image upon hearing a plural phrase before hearing the feedback ($M=94.8\%$), suggesting that they interpreted *ka* and *po* as plural markers. Our main research question was whether children can categorize a new speaker purely based on the learned association between grammatical patterns and alien group. Overall, children performed above chance ($M=61.1\%$, $\beta=1.051$, $SE=0.248$, $p<.001$). Further, they had significantly

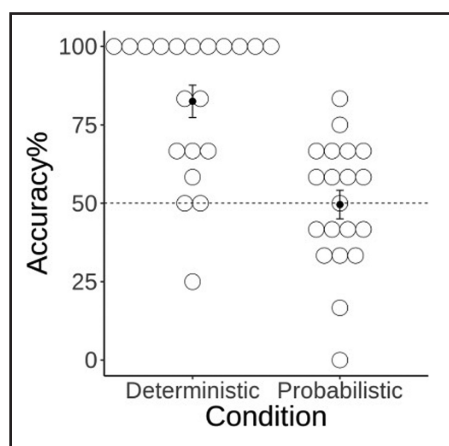


Figure 2 Test performance in the categorization test. Note: In the probabilistic condition, a response was counted as correct if the child selected the alien group more likely to produce the observed marker (i.e., Gulu for ka-dominant sequences, Norl for po-dominant sequences). Error bars are standard error, and the dashed line at 50% accuracy marks chance.

higher accuracy in the Deterministic condition compared to the Probabilistic condition ($\beta = 1.090$, $SE = 0.250$, $p < .001$) (Figure 2). Age was not a significant predictor of accuracy ($\beta = .13$, $SE = 0.232$, $p = .570$), suggesting stability in test performance across this age range (see Figure S2).

The models for each condition indicated that above-chance performance was driven by the Deterministic condition, which had a significantly positive intercept ($M = 82.5\%$, $\beta = 3.029$, $SE = 0.869$, $p < .001$), whereas the probabilistic condition did not ($M = 49.8\%$, $\beta = -.024$, $SE = 0.189$, $p = .898$) (Figure 2). Age remained a nonsignificant predictor in both models for each condition (deterministic: $\beta = .840$, $SE = 0.661$, $p = .204$; probabilistic: $\beta = -.165$, $SE = 0.191$, $p = .389$). Additionally, there was no difference in categorization accuracy between trained and new animal nouns in either condition (deterministic: $\beta = .167$, $SE = 0.499$, $p = .738$; probabilistic: $\beta = .017$, $SE = 0.135$, $p = .902$), indicating that children readily generalized the speaker-marker pattern to new lexical items (see Figure S3).

We note that the exclusion rate for the speaker attention check criterion ($n = 19$) was relatively high. As preregistered, children were required to achieve at least 80% accuracy on the eight speaker-attention checks (i.e., determine which speaker just spoke on the last trial), which allowed for only one error. To evaluate whether this criterion impacted the results, we conducted two exploratory analyses. First, we compared the ages of included and excluded children and found no significant difference ($M_{\text{included}} = 72.2$ months; $M_{\text{excluded}} = 71.2$ months), suggesting that age was not a systematic factor in exclusion. Second, we repeated the analyses under a more lenient threshold of 75% accuracy, which reinstated 12 of the 19 excluded children. The pattern of results was unchanged: we observed that the relaxed sample still had overall significantly above-chance performance ($M = 62.0\%$, $\beta = .773$, $SE = 0.206$, $p < .001$), and that children performed significantly better in the deterministic condition compared to the probabilistic Condition ($\beta = .805$, $SE = 0.209$, $p < .001$). Similarly, as revealed by the per-condition models, children in the deterministic condition performed significantly above chance ($M = 75.0\%$, $\beta = 2.069$, $SE = 0.568$, $p < .001$), whereas those in the Probabilistic

Condition did not ($M = 50.0\%$, $\beta = -.008$, $SE = 0.176$, $p > .964$). Age remained a nonsignificant predictor in both models in the relaxed sample (deterministic: $\beta = .802$, $SE = 0.508$, $p = .114$; probabilistic: $\beta = -.189$, $SE = 0.177$, $p = .285$). Thus, although the preregistered criterion may have been overly stringent for this age group, the main findings are robust to a more developmentally appropriate threshold.

Discussion

To examine whether children can use grammatical variation to infer speaker group membership, we conducted an interactive semi-artificial language learning task with 5- to 6-year-olds. We found that children reliably categorized new speakers when the linguistic pattern associated with group membership was deterministic but not when it was probabilistic. Categorization accuracy did not differ between trained and untrained nouns, suggesting that children may have generalized beyond specific word forms, potentially drawing on an underlying morphological pattern (i.e., plural marking). Age was not significantly correlated with performance, indicating that by age five, children can use consistent grammatical patterns to draw inferences about speakers. Importantly, the differences in how the two groups speak were never mentioned to the children, suggesting that they are sensitive to links between speaker groups and language patterns in the absence of explicit instruction. Importantly, the difference between the two groups' speech patterns was never mentioned to the children, suggesting that they were sensitive to links between speaker groups and language patterns even without explicit instruction. The speaker-attention checks may have modestly supported this learning by encouraging children to keep track of speaker identity throughout training.

Why, then, did children fail to show evidence of categorization in the probabilistic condition? One possibility is that probabilistic patterns are simply more difficult to learn and require more input to reach a threshold for generalization. Classic work on children's nonlinguistic probability learning provides some reference points for this possibility, as these studies often used substantially more exposure than the present study. For example, [Stevenson and Weir \(1959\)](#) found that 3-year-olds over-selected a probabilistically reinforced option after 80 trials in a 3-alternative task, though they appeared to prefer that option already in the first block. [Craig and Myers \(1963\)](#) found that kindergarteners showed only a modest shift from chance toward the more frequent option even after 200 two-alternative light-choice trials with an 80:20 input distribution. These findings indicate that such tasks are quite challenging for children in our age group.

Of particular relevance to the current study is prior work on children's learning of probabilistic linguistic patterns. This literature suggests that morphosyntactic variation is acquired gradually, with children initially learning categorical associations before acquiring more nuanced, probabilistic ones ([Shin & Miller, 2022](#)). For example, in Spanish, plural is typically marked by a word-final -s, but in some dialects, the word-final/s/is frequently omitted or reduced in pronunciation. Children acquiring Spanish dialects that allow/s/omission or reduction take longer to acquire plural marking than children learning dialects that don't ([Miller & Schmitt, 2010](#)). Previous work with artificial language learning paradigms also found that children have difficulty with learning probabilistically conditioned patterns for grammatical markers

(Kam, 2015; Samara et al., 2017). For example, Samara et al. (2017) found that children were able to track a deterministic mapping, select the correct marker when asked to guess on behalf of the speaker when one speaker consistently used one form and another speaker consistently used a different form. However, they failed to do so when speakers only probabilistically preferred one marker over the other. Similarly, children in our study may need more exposure before they can represent a probabilistic generalization such as: “Gulus are more likely to use *ka* than *po*.” Thus, it remains possible that with increased input, children would show above-chance categorization in the probabilistic condition. At the same time, the absence of learning in the probabilistic condition in Samara et al. (2017) was observed even after 4 days of training, suggesting that the amount of training needed is not trivial and that the lack of learning observed in the current study is unlikely to be explained solely by the brevity of training.

Another possibility is that children did track the probabilistic pattern but interpreted the test phase differently than we intended it. Under our current design, children were presented with a new speaker during the test who uses a particular plural marker distribution (e.g., 75% *ka*, 25% *po*) and had to decide which group that speaker likely belonged to. However, because both Gulus and Norls occasionally produced both forms, children may have judged either group as a plausible source. From a pragmatic perspective, their categorization responses might reflect the ambiguity inherent in probabilistic input. Future work could address this issue using a modified design: after exposure to probabilistic input, test speakers could produce a deterministic pattern (e.g., all *ka*), which would more clearly implicate the group that favored that form during exposure.

In sum, the present findings provide the first evidence that children can use a morphosyntactic pattern to infer speakers' group membership. These results demonstrate an early-emerging sensitivity to grammatical variation linked to speaker groups and offer a foundation for more complex sociolinguistic learning later in development. By integrating artificial language learning with speaker group manipulations, this study introduces a new methodological approach for investigating how children acquire sociolinguistic knowledge from distributional patterns in the input. Future research will move beyond artificial categories like our Gulus and Norls to include more meaningful groups that are based on the types of social categories children encounter in their everyday lives. In this way, we will begin to better understand how children learn to connect the way that people speak to the social groups to which they belong.

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Supplementary material

Supplementary material is available at *Child Development* online.

Data availability

All study material, data, and analysis code are openly available at the project's OSF page at https://osf.io/7znux/overview?view_only=97b8f5151fe94f788e82b477e0a03ca3 and https://osf.io/7q3nv/overview?view_only=9b2e7bc9bf1a4330a300cf9698c0490e. We have no conflicts of interest to disclose. This research received approval from the University of Wisconsin–Madison Institutional Review Board. We gratefully acknowledge funding from the University of Wisconsin–Madison to the third author.

Author contributions

We provide **Author contributions (CRediT)** below, following the submission guidelines. [First Author]: Conceptualization, Methodology, Investigation, Project administration, Data curation, Formal analysis, Visualization, Writing-original draft, Writing-review & editing; [Co-author 2]: Methodology, Validation, Writing-original draft; [Co-author 3]: Conceptualization, Methodology, Supervision, Funding acquisition, Resources, Writing-review & editing. All authors approved the final manuscript.

Yiran Chen (Conceptualization, Investigation, Methodology, Project administration, Visualization, Writing—original draft [lead]), Lynna Tran (Methodology, Validation, Writing—original draft [supporting]), and Jenny Saffran (Conceptualization, Methodology [supporting], Resources, Supervision, Writing—review & editing [lead])

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Conflicts of interest

The authors have no conflicts of interest.

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