ACCEPTED FOR PUBLICATION (POST-PEER REVIEW, PRE-COPYEDIT), *FIRST LANGUAGE*. PLEASE DO NOT CITE THIS VERSION.

Thought and Language: Association of Groupmindedness with Young English-speaking Children's Production of Pronouns

Jared VASIL[1,*], Charlotte MOORE[2], Michael TOMASELLO[1,3]

[1] Department of Psychology and Neuroscience, Duke University, Durham, NC, USA

[2] Department of Psychology, Concordia University, Montreal, Canada

[3] Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

* Corresponding author, jared.vasil@duke.edu

Keywords: pronouns, reference, first-person plural, production, shared intentionality

Acknowledgements: We thank Dayna Price for assistance with coding data for an earlier version of this research. We thank Stephen Meylan, anonymous reviewers, and an anonymous statistical consultant for insightful commentary and feedback on the manuscript.

Abstract

Shared intentionality theory posits that at age 3 children expand their conception of plural agency to include 3- or more-person groups. We sought to determine whether this conceptual shift is detectable in children's pronoun use. We report the results of a series of Bayesian hierarchical generative models fitted to 479 English-speaking children's first-person plural, first-person singular, second-person, third-person plural, and third-person singular pronouns. As a proportion of pronouns, children used more first-person plural pronouns, only, after 3;0 compared to before. Additionally, children used more 1pp. pronouns when their mothers used more 1pp. pronouns. As a proportion of total utterances, all pronoun classes were used more often as children aged. These findings suggest that a shift in children's social conceptualizations at age 3 is reflected in their use of 1pp. pronouns.

Thought and Language: Association of Groupmindedness with Young English-speaking Children's Production of Pronouns

Pronouns are a common type of referring expression. For children, the appropriate use of these forms presents unique discourse-pragmatic and grammatical challenges (reviewed in Tomasello, 2003). Discourse-pragmatically, pronouns are used to refer to varied referents, but only when common ground enables joint attention to referents without nominalization (e.g., using *it* instead of *the ball* when the ball is discourse topical; Clark & Marshall, 1981). Moreover, personal pronouns are deictics and thus require perspective-taking for appropriate use (Langacker, 2007).

Grammatical difficulties also exist. For instance, in some languages pronouns are marked for case (Comrie, 2013), and children occasionally have trouble mastering this marking (e.g., Kirjavainen et al., 2009; Rispoli, 1998). Nevertheless, children use pronouns appropriately from around 2 years old (Girouard et al., 1997). Indeed, a large body of literature speaks to 2-year-olds' ability to appropriately produce (reviewed in Vasil, 2022) or comprehend personal (e.g., Bohn et al., 2020), possessive (e.g., Charney, 1980), and reflexive pronouns (e.g., Matthews et al., 2009).

However, little is known about children's first-person plural (1pp.) pronouns.[1] There are two studies of which we are aware. One investigated older, atypically-developing children's use of *we* (Hobson et al., 2010). More relevant is an investigation of young children's pronouns by Ibbotson et al. (2018). These authors investigated the relative frequencies of 10 English-speaking and 4 Swedish-speaking children's pronouns relative to their input frequency. It was reported that, after controlling for input, 1pp. forms were underrepresented in the speech of all children (i.e., relative to 1pp. input frequency). Indeed, although children began to use relatively more 1pp. forms

[1] First-person singular and plural, second person, and third person singular and plural are abbreviated 1ps., 1pp., 2p., 3ps., and 3pp., respectively. Because they are formally identical in English, undistinguished are 2ps. and 2pp.

compared to input frequency by 30 to 36 months of age, 1ps. forms dominated throughout and, in fact, increased in frequency across the sampling period (English: 18-62 months; Swedish: 19-47 months). The conclusion advanced by Ibbotson et al. (2018) was one of cognitive development impacting language use. Citing Piaget (1926) and Vygotsky (1962), those authors suggested that early pronoun development is related to "underlying cognitive and social biases" that guide language use in the context of "communicative goals that are relevant to the child," (Ibbotson et al., 2018, p. 1330). This conclusion advances our understanding of children's use of 1pp. pronouns.

The next step is to inquire into the specifics of the developmental pathway that influences children's use of 1pp. forms. There are two questions to ask. First, what is the pathway? Second, how might that pathway influence children's use of 1pp. forms? The present article suggests answers to these questions, first by proposing that shared intentionality theory (Tomasello, 2019) may provide a pathway and second, by reporting evidence that suggests a role for the pathway in guiding 2- to 5-year-old English-speaking children's use of 1pp. pronouns.

Shared intentionality theory proposes that children undergo a conceptual shift at 3;0. This shift targets children's conceptualization of social relations during collaborative activity. Before 3;0, children represent themselves and collaborative partners as constituting a dyadic, joint agent "we" during collaboration. This representation is manifest in behaviors like role reversal and turn taking (e.g., Warneken et al., 2006). Then, at 3;0, a kind of "groupminded turn" causes children to extend their conception of plural agency to include – in addition to dyads – groups composed of three or more people. This manifests as "groupmindedness," in which children conceptualize themselves and partners as bound to norms and conventions (e.g., Rakoczy et al., 2008).

To appropriately use a word, children must first be able to conceptualize the word's referent (Langacker, 1987; Tomasello, 2003). Following the hypotheses of shared intentionality theory, for

1pp. reference there are two relevant referent "types," namely, dyads and groups. Thus, from this perspective, mature control of 1pp. pronouns requires that children be able to conceive of dyads and groups before they can refer to them. We propose that the groupminded turn is necessary before children can fully make use of 1pp. pronouns. The key point is that, according to shared intentionality theory, children's conception of the number of people that can constitute plural agents expands across development. A shift occurs at 3;0 with the groupminded turn. Before the groupminded turn, by hypothesis, children can use 1pp. reference to refer to dyads only (self + other), whereas, after the turn, children can use 1pp. pronouns to refer to both dyads and groups. In other words, the groupminded turn expands the set of conceivable plural person referents.

We argue that this increase ought to be detectable in how often children use, specifically, 1pp. pronouns. Our reasoning was that plural pronominal person reference may mirror its singular counterpart in its dependence on perspective taking skills. Ricard et al. (1999) found that children's ability to coordinate two (three) visual perspectives precedes their ability to appropriately use 1ps. and 2ps. (3ps.) forms. Our hypothesis for children's plural pronominal reference posited a similar reliance on perspective taking. Children most readily assume shared perspectives during collaborative activities with others (reviewed in Tomasello, 2019). That is, children have an easier time adopting partners' perspectives when actively collaborating with them (e.g., Moll et al., 2007). Thus, if plural pronominal person reference relies on shared perspectives – the perspective of "we" –, then it may be that the emergence of groupmindedness uniquely impacts 1pp. reference. This is because the pragmatics of the type of situation in which children most easily adopt shared perspectives – collaboration – characteristically pulls for reference using, e.g., *we* and not *them*.

This article investigates these claims through quantitative analyses of English-speaking children's use of 1pp. pronouns. To contextualize this investigation, we additionally investigated children's 1ps., 2p., 3pp., and 3ps. pronouns. The analyses focused on the association of the groupminded turn with two measures of pronoun relative frequency, namely, pronoun use as a proportion of pronouns and as a proportion of utterances. The former provides information about which pronouns children use when they use pronouns, whereas the latter provides information about how often children use pronouns in their speech as a whole. We predicted that the groupminded shift at 3;0 would manifest in a proportionally increased use of 1pp. pronouns, specifically. Input relations were also investigated. Children were predicted to use proportionally more 1pp. pronouns when mothers did so (Ambridge et al., 2015; Goodman et al., 2008).

Methods

R code sufficient to obtain all data and reproduce all analyses, results, figures, and tables in the Main Text and Supplementary Material is freely available at https://osf.io/65wex/.

Corpora. Transcripts were pulled from the CHILDES database collections "Eng-NA" (North American English) and "Eng-UK" of children between 24.0 and 72.0 months of age at recording (MacWhinney, 2014). This was done in R (R Core Team, 2013) via the childesr (version 2021.1; Sanchez et al., 2019) font-end interface to childes-db. This left 536 children across 58 corpora. Transcripts were further filtered to ensure that the Target Child (i) said at least 10 unique words; (ii) had a mother who said at least 10 unique words; and (iii) had a name in the transcript.

Filtering by these criteria left 479 children across 37 corpora (see Supplementary Table 1 for corpora). Data from these 37 corpora were binned, for each child, into 0.1-month age bins for each age in which the child used at least one 1pp., 1ps., 2p., 3pp., or 3ps. pronoun (see below). Using this method, the corpora included age bins that ranged from 24.0 to 70.4 months, with median 32.2 months and mean 34.7 months (SD = 9.1).

Pronoun Classes. Using token classifications in the childes-db dataset, all personal, possessive, and reflexive pronoun tokens were extracted from the 37 corpora. All 2ps. and 2pp. pronouns were grouped together because singular and plural *you* are formally indistinguishable. Each pronoun class included the corresponding personal, possessive, and reflexive forms. Pronoun classes included: 1ps. (*I, me*, *mine*, *myself*), 1pp. (*we, us, ours*, *ourselves*), 2p. (*you*, *yours*, *yourself*), 3ps. (e.g., *she, him*, *hers*, *himself*), and 3pp. (*they, them*, *theirs, themselves*).

Dataset Structure. Age was binned into 0.1-month bins by rounding the childes-db age to the nearest tenth. Binning was performed on six datasets, one for pronoun use relative to total pronouns ("pronoun proportions") and five relative to total utterances ("utterance proportions"). Children contributed data in age bins in which they used at least one pronoun. For example, if Child X was recorded using one pronoun at 25.3 months (e.g., one 1pp. token), then Child X was recorded as having used one 1pp. pronoun and zero 1ps., 2p., 3pp., and 3ps. pronouns at 25.3 months. Age bins in which children never used pronouns were removed. This resulted in 356 age bins spread across 479 children. There were 2,486 unique child-age bin pairs (i.e., observations) in each of the six datasets. In the pronoun proportions dataset, rows contained information on child name, age, sex, corpus, the number of pronouns of each class that the child used at that age (e.g., 10 1pp., 10, 1ps., 10, 2p., 10 3pp., and 10 3ps.), the total number of pronoun tokens that the child used at that age (e.g., 50 total pronouns), and the maternal pronoun proportion (e.g., 0.20 of child X's mother's pronouns were 1pp. at 25.3 months). For each pronoun proportions observation, the sum of the values across the pronoun class counts, divided by the total pronoun count, equaled 1. In the five utterance proportions datasets, rows contained information on child name, age, sex, corpus, the number of unique utterances that contained a given pronoun class (e.g., 10 unique utterances contained 1pp.), the number of unique utterances that the child used at that age (e.g., 200 unique utterances), and the maternal utterance proportion (e.g., 0.20 of child X's mother's utterances contained 1pp. at 25.3 months). There was one utterance proportion dataset per pronoun class.

Splitting Datasets into Before Groups and After Groups. The data in all six datasets was split at 36.0 months. This left two subsets in each dataset: the "Before Groups" subset, which included observations from 24.0 to 35.9 months; and the "After Groups" subset, which included observations from 36.0 to 70.4 months. Overall, there were 430,782 child and 1,005,545 maternal pronouns tokens, and 1,343,740 child and 1,508,276 maternal utterances. Utterances in which children used a specific pronoun class twice (e.g., *we are going to our house!*) were only counted once for that pronoun class (i.e., duplicate utterances were removed so that a pronoun class could be observed at most once per utterance). Supplementary Table 2 provides additional descriptive statistics about the data. Supplementary Figure 1 displays the total number of pronouns and utterances contributed by children in each age bin. Supplementary Figure 2 displays the number of age bins contributed by each child; the caption provides additional information about the composition of age bin contributions by children. Table 1 summarizes the data. Supplementary Figure 1 displays the total number of pronouns and utterances contributed by children in each age bin. Supplementary Figure 2 displays the number of age bins contributed by each child; the caption provides additional information about the composition of age bin contributions by children.

Analysis. Bayesian hierarchical generative models were fitted to the data. Bayesian inference consists in quantifying inferential uncertainty in terms of probability statements (Gelman et al., 2013). Accounting for uncertainty is important for inferential reliability and stability (Wasserstein et al., 2019). Moreover, a Bayesian approach allows for intuitive interpretations of fitted models, e.g., "Given the model and data, we are X% confident that effect Y exists" or "Given the model and data, there is a 95% chance that parameter X takes a value between A and B." This is an important benefit of Bayesian inference, as this sort of straightforward, probabilistic interpretation is sometimes applied, incorrectly, to Frequentist *p*-values (Cassidy et al., 2019) and confidence intervals (Kruschke & Liddell, 2018), respectively. In a regression setting, Bayesian inference (with flat priors) can be understood as generalizing the Frequentist approach from inferences about point estimates to inferences about the distribution over point estimates (Gelman et al., 2020).

Wrangling was performed with tidyverse (Wickham et al., 2019); models sampled with Stan (Stan Development Team, 2022) via brms (Bürkner, 2017); figures produced with tidyverse, bayesplot (Gabry & Mahr, 2022), tidybayes (Kay, 2022), and patchwork (Pedersen, 2022).

Pronoun Proportions. Data were divided into pronoun proportions and utterance proportions. Pronoun proportions were the relative frequency of pronoun classes as a proportion of pronouns used (e.g., 10% of Child X's pronouns at 25.3 months were 1pp. pronouns). The pronoun proportions data satisfied the assumptions of the hierarchical multinomial model (brms family "multinomial," multinomial logit link). The data included crossed and nested grouping factors ('hierarchical') and an unordered simplex multivariate discrete response ('multinomial'). The latter requires that the sum of pronoun class counts, divided by the total pronouns, equals 1 per observation. The simplex property is requisite because the multinomial likelihood models a *K*-dimensional probability vector, which sums to 1 over *K*. Here, we model a 5-dimensional random vector that captures the conditional probability of children's 1pp., 1ps., 2p., 3pp., and 3ps. pronouns. Thus, we modeled the generative process "directly," that is, without transforming outcomes into proportions. This is important because observing, e.g., two pronouns with one 1pp. token is less informative for making inferences about the generative process than is observing 200 pronouns with 100 1pp. tokens (Lo & Andrews, 2015).

We modeled the probability of the multivariate outcome conditional on the groupminded turn and other covariates. A continuous age term was included in the model to ensure that associations between the outcome and groupmindedness were related to the groupminded shift, *per se*. The hierarchical structure captured sources of variation and correlation among grouping factors (Oberauer, 2022). Posterior predictive checks indicated the utility of including observation-level random intercepts to account for overdispersion (Harrison, 2014). The model formula was:

vector of pronoun class counts | count of total pronouns ~ 1,

<u>mean of 1pp.</u> ~ continuous age + child sex + before/after 3;0 * maternal proportion 3pp. + before/after 3;0 * **maternal proportion 1pp**. + (continuous age + before/after 3;0 * **maternal proportion 1pp**. | corpus : child) + (continuous age + child sex + maternal proportion 3pp. + **maternal proportion 1pp**. | corpus) + (1 | observation)

<u>mean of 1ps.</u> ~ continuous age + child sex + before/after 3;0 * maternal proportion 3pp. + before/after 3;0 * **maternal proportion 1ps**. + (continuous age + before/after 3;0 * **maternal proportion 1ps**. | corpus : child) + (continuous age + child sex + maternal proportion 3pp. + **maternal proportion 1ps**. | corpus) + (1 | observation)

<u>mean of 2p.</u> ~ continuous age + child sex + before/after 3;0 * maternal proportion 3pp. + before/after 3;0 * **maternal proportion 2p**. + (continuous age + before/after 3;0 * **maternal proportion 2p**. | corpus : child) + (continuous age + child sex + maternal proportion 3pp. + **maternal proportion 2p**. | corpus) + (1 | observation)

<u>mean of 3ps.</u> ~ continuous age + child sex + before/after 3;0 * maternal proportion 3pp. + before/after 3;0 * **maternal proportion 3ps**. + (continuous age + before/after 3;0 * **maternal proportion 3ps**. | corpus : child) + (continuous age + child sex + maternal proportion 3pp. + **maternal proportion 3ps**. | corpus) + (1 | observation)

For ease, terms that differed between the distributional means formulas are bolded. Children's 3pp. data was the outcome reference category. Age and maternal proportions were continuous; groupmindedness (before 3;0, after 3;0) and child sex (male, female) were discrete variables. Discrete variables were sum coded; continuous variables were grand mean centered and standardized following Gelman (2008). This model assumed that pronoun class probability depends on child age, sex, groupmindedness, maternal pronoun proportion, and the interaction of the latter two; and that these dependencies varied by child or corpus. The random effects structure was chosen by pruning random slopes with posterior SDs near 0 from a fuller random effects structure. For further justification of model parameterization, please see Appendix Table, caption.

Utterance Proportions. Utterance proportions were the relative frequencies of utterances that contained pronoun classes as a proportion of total utterances (e.g., 10% of Child X's utterances at 25.3 months contained 1pp. pronouns). This data was modeled with a special case of the multinomial distribution, namely, the binomial distribution, in which K equals 2 with a univariate outcome (i.e., the probability of success, given n trials with m successes). Because utterance proportions did not sum to 1 across pronoun classes, each class was modeled as generated by independent binomial processes (brms family "beta-binomial"). This resulted in 5 unique utterance proportions models. Each model estimated the conditional probability of children using one pronoun class in an utterance, rather than any other class. For instance, the binomial model of 1pp. utterance proportions captured children's tendency to use 1pp. pronouns in an utterance, as opposed to the other four pronoun classes. The model formula for all binomial models was

count of unique pronoun class utterances | count of total unique utterances ~ continuous age + child sex + before/after 3;0 * maternal proportion + (continuous age + before/after 3;0 * maternal proportion | corpus : child) + (child sex + before/after 3;0 * maternal proportion | corpus)

The utterance proportions models accounted for similar sources of uncertainty as the pronoun proportions model. However, the former included a distributional parameter (phi) that was absent from the multinomial model and that accounted for potential overdispersion (Winter & Bürkner, 2021). Logit and identity links were used for binomial mean and variance, respectively.

Priors. Weakly to moderately informative priors were placed over parameters (see code; Lemoine, 2019). Main and interaction fixed effects priors were $\beta \sim N(0, 1)$ and $\beta \sim N(0, 1.25)$, respectively.

Model Checks. Inferences were robust to flatter and peakier fixed effects priors. Models did not generate impossible data per graphical prior predictive checks (Gabry et al., 2019). Posterior checks included inspection of trace plots, graphical posterior predictive checks, and numerical estimates of posterior predictive *p*-values (Rubin, 1984). Graphical checks were adequate (see code). Analysis of p-values suggested that the mean and SD of posterior-generated datasets were plausible (as per Gelman et al., 2013). Samplers ran 7 chains with no divergences (multinominal model: 3000 iterations, 1500 warmup; binomial models: 4000 iterations, 1250 warmup); R-hats were less than or equal to 1.01; effective sample sizes were adequate (as per Gelman et al., 2013).

Model Interpretation. The expectations of model posterior predictive distributions were investigated (via brms “conditional_effects” and tidybayes “epred_draws”). Posterior predictive distributions represent fitted model predictions about future, unseen data after averaging across (that is, accounting for uncertainty in) the posterior parameters. Investigation of posterior predictive distributions enables intuitive interpretation of the fitted models in terms of (i) the conditional probabilities of children using the pronoun classes (Figs. 3 and 5) and (ii) marginal association sizes on the probability scale (Fig. 4 and 6). All posterior draws were used to generate posterior predictive distributions. Please see Appendix Table for posterior parameter estimates.

Results

Data visualization. This subsection of the Results Section visualizes and describes qualitative data patterns. Inferential statistics are reported in the subsection entitled “Model Interpretation.”

Children. Figure 1 visualizes the relative frequencies of children’s pronoun use before and after 3;0. (Supplementary Figure 3 depicts the data by month). Pronoun proportions of 1pp., 2p., and 3pp. pronouns increased after the groupminded shift (Fig. 1A). In contrast, pronoun proportions of the singular pronouns remained stable (1ps.) or decreased (3ps.) with the emergence of groupmindedness. However, 1ps. and 3ps. were the most frequently used pronoun classes before and after 3;0. In contrast, 3pp. and, especially, 1pp. pronouns were relatively infrequently used by children. Utterance proportions of all pronoun classes increased after 3;0 (Fig. 1B).

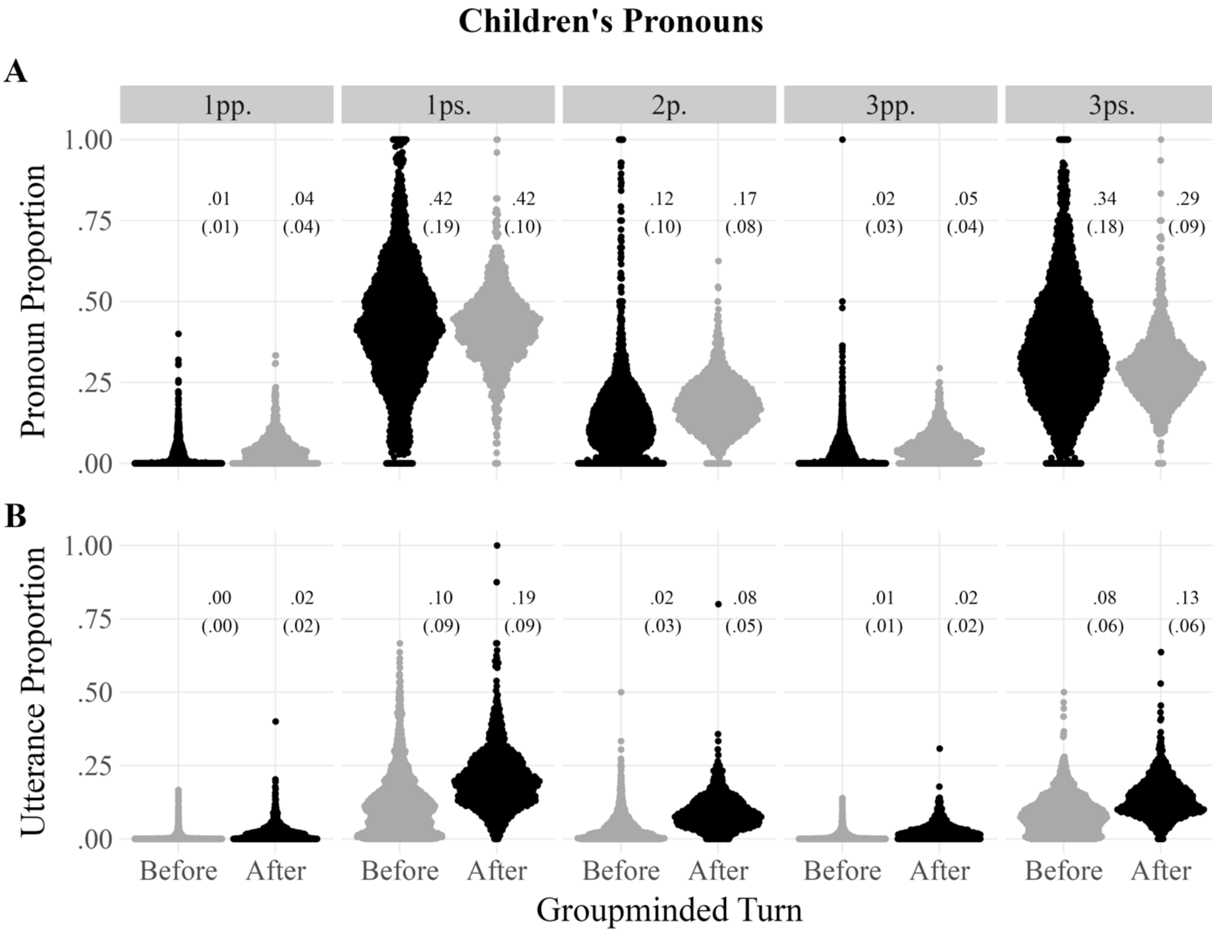

Figure 1. *Panel A*: Pronoun proportions. *Panel B*: Utterance proportions. Dots represent the observed value of the proportion for a specific child in a specific age bin. Thus, there are 2,486 dots per facet. Dots jittered to display density. *Y*-axes represent proportion; *x*-axes represent the groupminded turn (before or after 3;0). Facet inset: Value of data median (top row) and median absolute deviation (bottom row) of the data, rounded to hundredths.

Mothers. Figure 2 displays maternal pronoun data (Supplementary Figure 4 depicts the data by month). Mothers' 1pp. pronoun proportions decreased after the groupminded turn, whereas their 1ps. pronoun proportions increased (Fig. 2A). Moreover, 1ps. pronoun proportions were, on average, less than 2p. pronoun proportions. Maternal utterance proportions showed nondecreasing use of most pronoun classes after the groupminded turn at 3;0 (Fig. 2B). The only exception was 1pp. utterance proportions, which decreased after the groupminded turn. In sum, mothers' 1ps. and 3pp. pronoun proportions increased after 3;0 compared to before, while 1pp., 2p. and 3ps. pronoun proportions decreased. Only maternal 1pp. utterance proportions decreased after 3;0 (Fig. 1B).

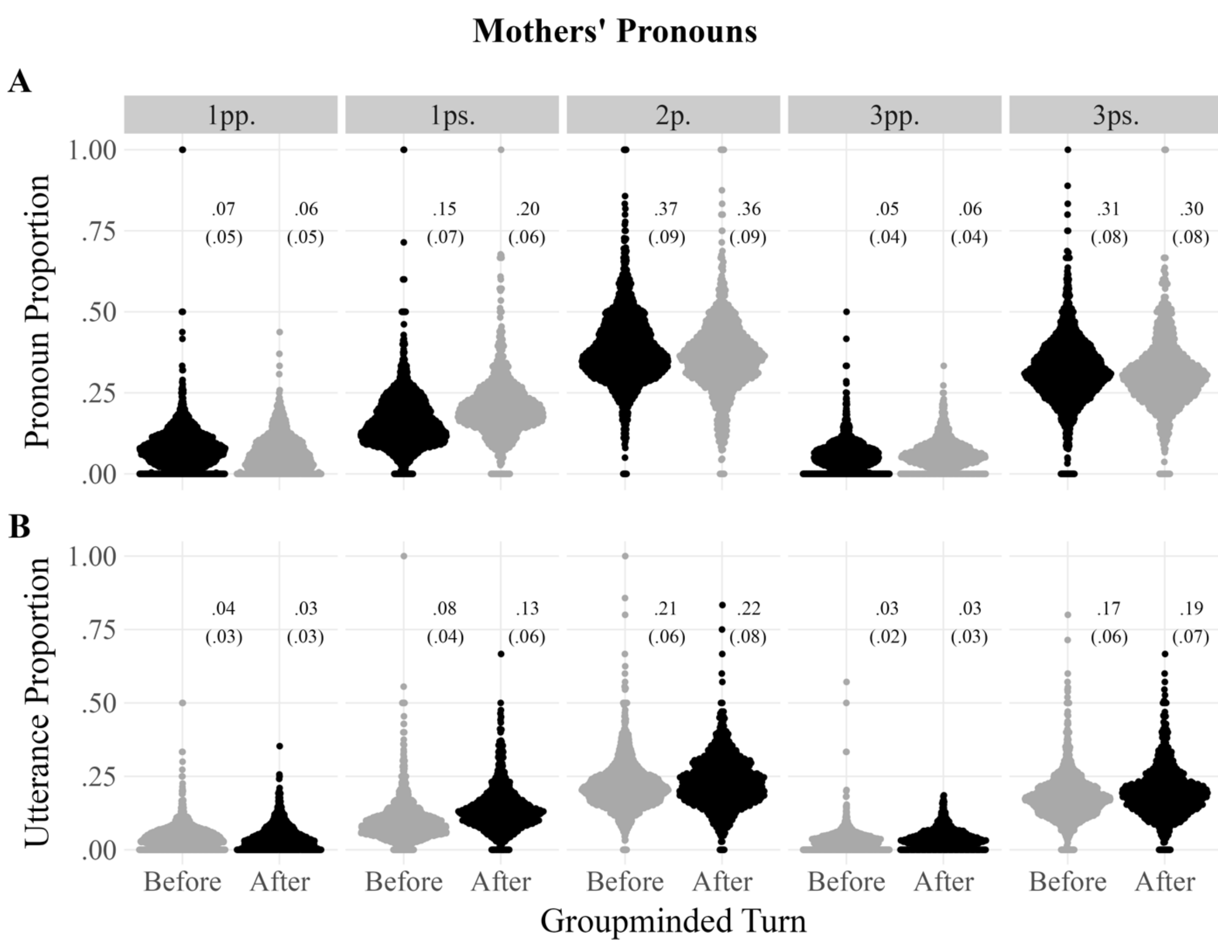

Figure 2. Mothers' pronouns before and after the groupminded turn at 3;0. Organized identically to Fig. 1.

Model Interpretation. ***Pronoun Proportions***. Figure 3 displays posterior predicted associations between the predictors and children's pronoun proportions. The first row, first column of Fig. 3 displays the posterior predicted pronoun proportion of 1pp. before and after the groupminded turn at 3;0. The groupminded turn was associated with a median 1pp. pronoun proportion increase of 0.64%. Specifically, before 3;0, 2.44% of children's pronouns were predicted to be 1pp., whereas after 3;0 this increased to 3.08%. This association existed alongside a positive relationship between 1pp. use and age (first row, second column). Additionally, there was a positive relation between mothers' and children's 1pp. forms (first row, third column). After the groupminded turn, there was some evidence that children's 1pp. pronoun proportions were more strongly related to their mothers' 1pp. pronoun proportions than before. This was indicated by the posterior predicted median line for the After Groups set falling in the upper quartile of the 95% highest density interval (HDI) of the Before Groups set (first row, fourth column). This suggests the possibility that the association between children's and mothers' 1pp. pronoun proportions is stronger after the groupminded turn than before. Overall, these results suggest that children's 1pp. pronoun proportions are greater after the groupminded turn than before, and that children's 1pp. pronoun proportions increase with increasing age and maternal 1pp. pronoun proportions.

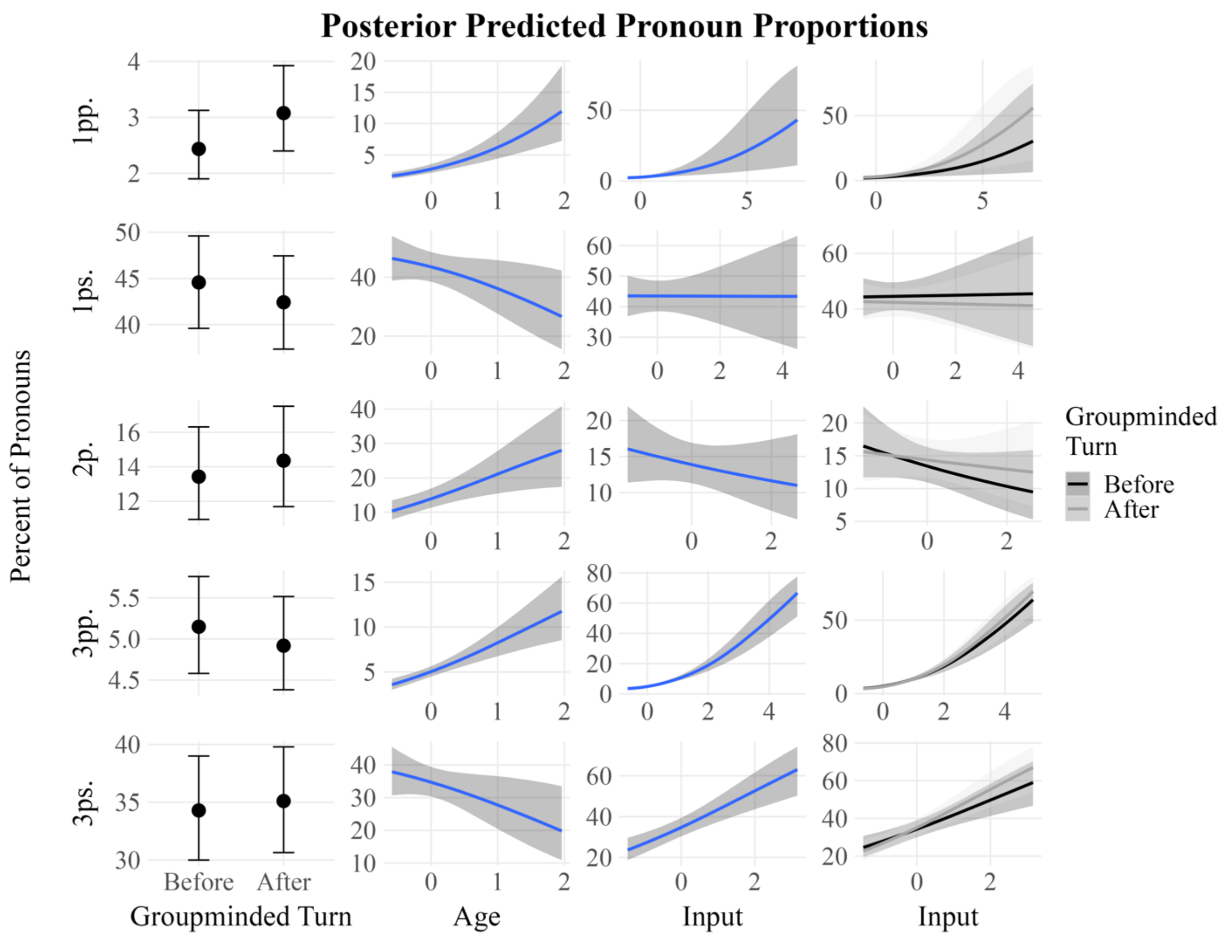

Figure 3. Rows display pronoun classes and columns display predictors. *X*-axes denote before or after 3;0 (first column), standardized age (second column), or standardized maternal input pronoun proportion (third and fourth columns); 0 indicates the median. *Y*-axes denote percent. Inset displays posterior predicted medians (dots, lines) and 95% HDIs (whiskers, bands). Posterior predictions are conditional on continuous predictor medians and averaged across categorical predictor levels.

No other pronoun class pronoun proportions showed the same association with groupmindedness. Posterior predictive distributions suggested a slight decrease in the median pronoun proportions of 1ps. (Fig. 3, second row, first column) and 3pp. (fourth row, first column) with the groupminded turn. In contrast, there was a slight, unreliable increase in the median proportion for 2p. (third row, first column) and 3ps. (fifth row, first column) with the groupminded turn. In some, particularly interesting cases, the nominal association between the groupminded turn and pronoun proportions contrasted with the posterior association between the groupminded turn and pronoun proportions but aligned with the posterior association between continuous age and pronoun proportions. For example, 3pp. pronoun proportions nominally increased after the groupminded turn (Fig. 1A). However, 3pp. pronoun proportions had a negative posterior predicted association with the groupminded turn (Fig. 3, fourth row, first column). Instead, 3pp. pronoun proportions were more positively related to continuous age than to the groupminded turn (fourth row, second column). On the other hand, a nominal decrease in 3ps. pronoun proportions after the groupminded turn (Fig. 1A) was likely due to a relatively large, negative posterior predicted association with age (Fig. 3, fifth row, second column) than to a relatively small, positive association with the groupminded turn (fifth row, first column). Thus, nominal 3pp. and 3ps. pronoun proportions may be more closely related to continuous age than to the groupminded turn. Like 1pp., children's 3pp. (fourth row, third column) and 3ps. (fifth row, third column) pronoun proportions were positively associated with maternal input. In contrast, children's 1ps. (second row, third column) and 2p. pronoun proportions (third row, third column) were relatively unrelated to maternal input. There was limited evidence for an interaction between groupmindedness and input for non-1pp. pronoun classes (second through fifth rows, fourth column). In sum, children used proportionally more 1pp. pronouns, and only 1pp. pronouns, after the groupminded turn than before. Children's 1pp., 3pp., and 3ps. pronoun proportions increased as their mothers' increased.

Figure 4 displays uncertainty about the size and direction of the associations displayed in Fig. 3. Like Fig. 3, rows in Fig. 4 display pronoun classes and columns display predictors. The first row, first column of Fig. 4 indicates that 97% of posterior predictive draws indicated that 1pp.

pronoun proportions were greater after 3;0 than before. Moreover, the 95% HDI of the distribution (horizontal black line; dot at median) excluded negative values (orange density), 95% HDI = [0.01, 1.21]. This suggests that 1pp. pronoun proportions increase after the groupminded turn, given the model and data. Additionally, 100% of posterior predictive draws included a positive association between age and 1pp. pronoun proportions (first row, second column) and maternal input and 1pp. pronoun proportions (first row, third column). This suggests that children's 1pp. pronoun proportions increase with age and input, given the model and data. 91% of posterior predictive draws indicated that the association between maternal and children's 1pp. pronoun proportions was more positive after the groupminded shift (first row, fourth column). This provides some evidence that children's use of 1pp. pronouns is more strongly associated with mothers' after the groupminded turn than before, given the model and data. Overall, these results suggest that children's 1pp. pronoun proportions increased after the groupminded turn. Moreover, children's 1pp. pronoun proportions increased as their mothers' 1pp. pronoun proportions increased.

No other pronoun class showed a similar association with groupmindedness (Fig. 4). Regarding age, 2p. (third row, second column) and 3pp. pronoun proportions (fourth row, second column) were positively related to child age, while 1ps. (second row, second column) and 3ps. pronoun proportions (fifth row, second column) were negatively related. As suggested above, 1ps. (second row, third column) and 2p. pronoun proportions (third row, third column) were unreliably related to input, whereas 3pp. (fourth row, third column) and 3ps. pronoun proportions (fifth row, third column) increased with increased exposure to those forms. There were no reliable interactions between groupmindedness and input among non-1pp. forms (second through fifth rows, fourth column). Overall, these results suggest that only children's 1pp. pronoun proportions were reliably related to the groupminded turn. Moreover, children's 1pp., 3pp., and 3ps. pronoun proportions increased when their mothers' corresponding pronoun proportion increased.

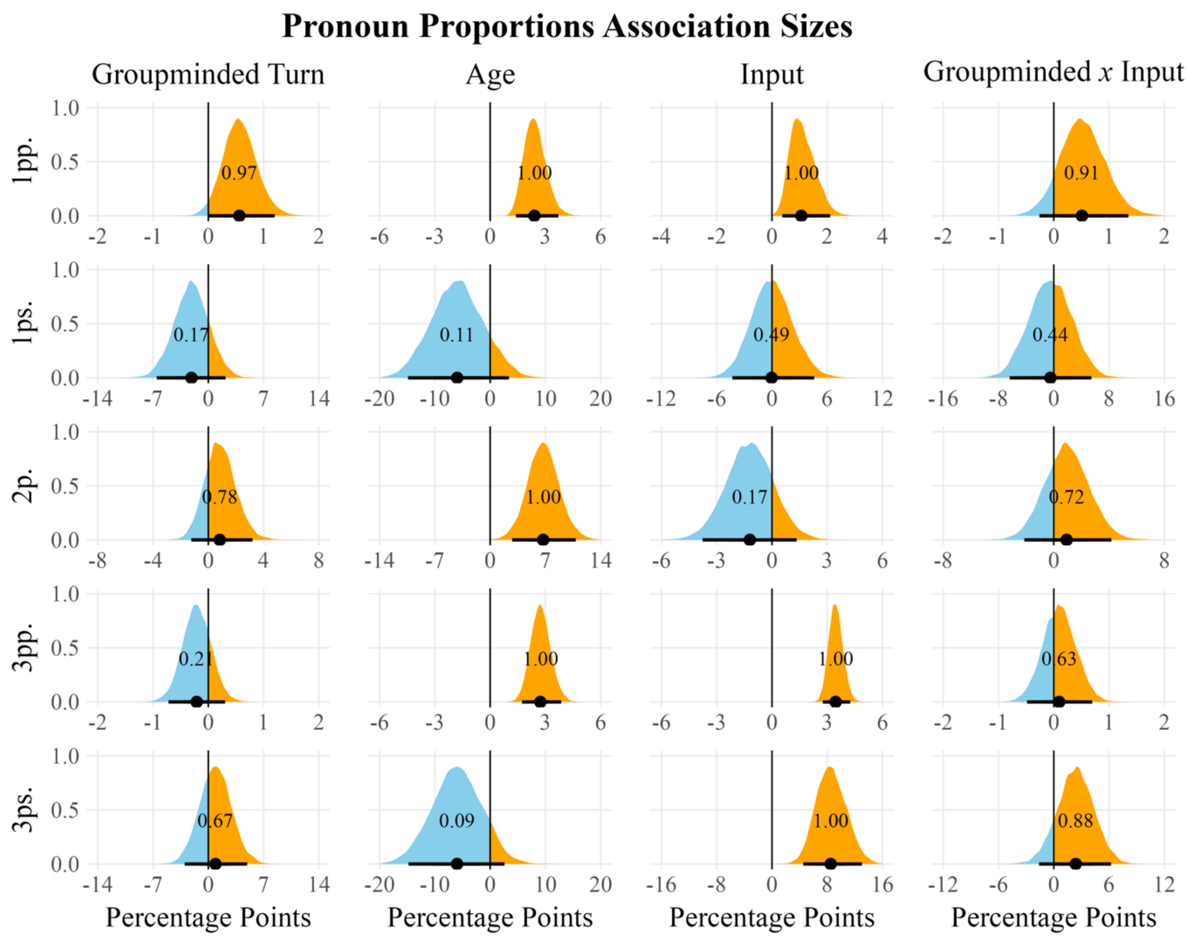

Figure 4. Pronoun proportions marginal association sizes computed from the posterior predictions displayed in Figure 3. Individual plots represent density of marginal effect sizes computed from posterior predictive draws. The first column displays posterior predicted marginal association sizes with the groupminded turn at 3;0 (e.g., 97% of posterior predictive draws indicated that children who have undergone the groupminded turn have higher 1pp. pronoun proportions than children who have not yet undergone the groupminded turn). The second column displays associations with age when comparing children at -1 SD and +1 SD from median age (e.g., 11% of posterior

predictive draws indicated that children 1 SD above the median age had greater 1ps. pronoun proportions than children 1 SD below the median age). The third column displays associations with input when comparing input at -1 SD and +1 SD from median input (e.g., 17% of posterior predictive draws indicated that children 1 SD above median 2p. pronoun proportions input had greater 2p. pronoun proportions than children 1 SD below median input). The fourth column displays that of the interaction of the groupminded turn (i.e., before/after 3;0) and input (i.e., at -1 SD and +1 SD). Orange portion of density indicates density over positive values; inset number quantifies the proportion of density over positive values, given the model and data. Rows display pronoun classes and columns display predictors. *X*-axes represent percentage points. Note the varying *x*-axis domains; these correspond to the varying ranges of the *y*-axes in Fig. 3 and reflect differences in the absolute size of associations with predictors across pronoun classes. Insets indicate the posterior predictive median (black dot) and 95% HDI (black horizontal line).

In sum, these results align with our predictions. Children used proportionally more 1pp. pronouns after the groupminded turn than before. They did not do so for other pronoun classes. Moreover, children used proportionally more 1pp. pronouns when their mother used more.

Utterance Proportions. Fig. 5 displays posterior predicted associations between predictors and children's utterance proportions. There was little evidence of associations between utterance proportions and groupmindedness (first through fifth rows, first column). Instead, utterance proportions were more closely related to continuous age. Specifically, utterance proportions of all pronoun classes were predicted to increase with continuous age (first through fifth rows, second column). Likewise for maternal input. Specifically, the more mothers used a pronoun class, the more their children used that pronoun class (first through fifth rows, third column). However, there was some evidence that this relation depended on groupmindedness. Specifically, children's 1ps. (second row, fourth column), 3pp. (fourth row, fourth column), 3ps. (fifth row, fourth column), and, to a lesser extent, 2p. utterance proportions (third row, fourth column) were more positively associated with their mothers' corresponding utterance proportions before the groupminded turn than after. The only exception was children's 1pp. utterance proportions (first row, fourth column), for which there was no interaction between the groupminded turn and maternal input. Overall, children's utterance proportions were not clearly related to the groupminded turn. However, children's utterance proportions increased with increasing age and maternal utterance proportions. The latter was especially true before the groupminded turn for all pronoun classes, except 1pp.

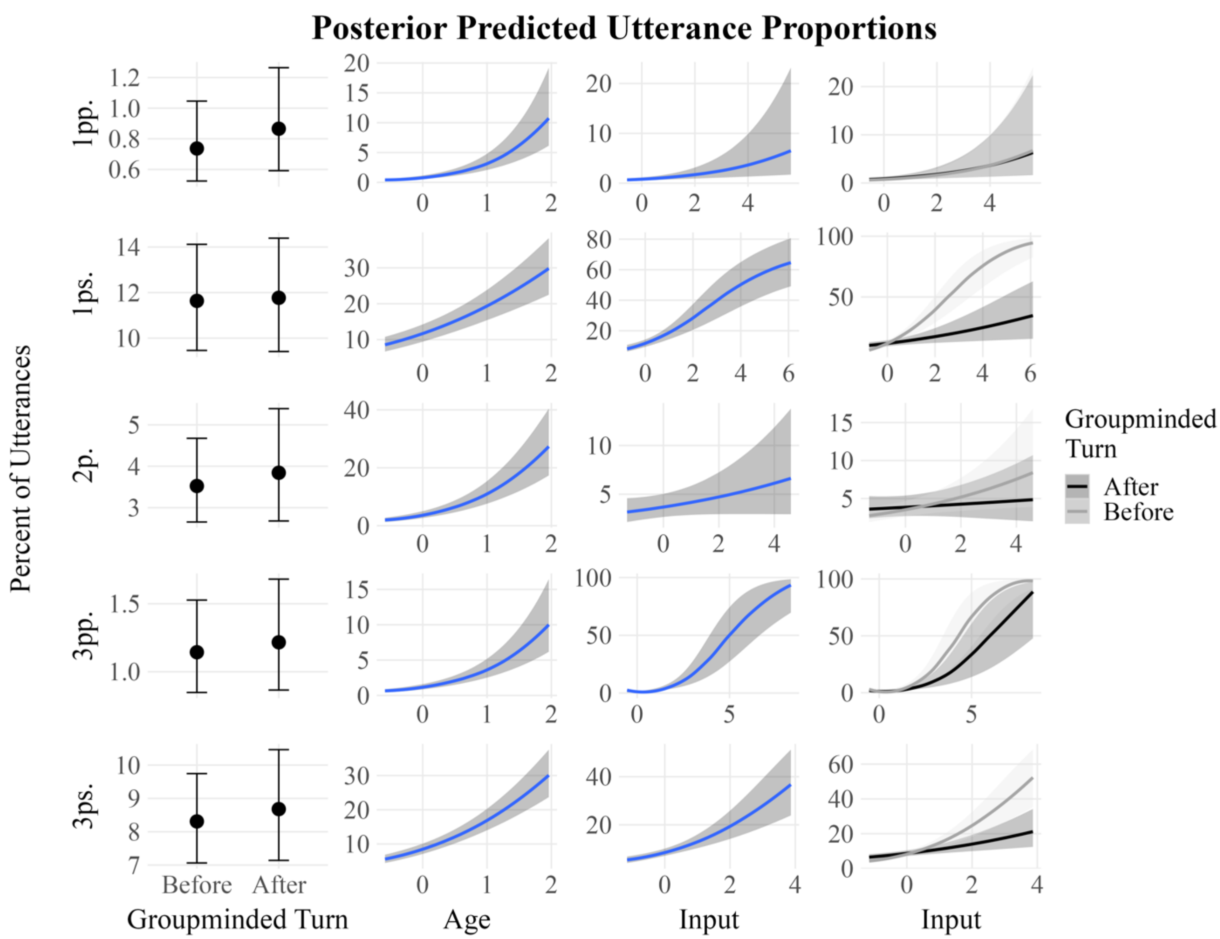

Figure 5. Organized identically to Fig. 3. Age and maternal input *x*-axes represent standardized values.

Fig. 6 summarizes uncertainty about the size and direction of the associations reported in Fig. 5. All pronoun classes were unreliably associated with groupmindedness, with 67% (1ps.) to 81% (1pp.) of posterior predictive draws indicating positive associations with the groupminded turn (first through fifth rows, first column). Rather, children's utterance proportions were more closely associated with continuous age than with groupmindedness. Specifically, in all models, 100% of posterior predictive draws indicated a positive association with continuous age (first through fifth rows, second column). In sum, there was little evidence for associations between children's utterance proportions and the groupminded turn at 3;0. Rather, children used all pronoun classes in proportionally more utterances as they aged.

Associations with maternal input were similarly positive, with 100% of posterior predictive draws for 1pp. (Fig 6., first row, third column), 1ps. (second row, third column), 3pp. (fourth row, third column), and 3ps. (fifth row, third column) utterance proportions models indicating a positive association with the input; the sole exception was 2p. (third row, third column), although there was still some evidence for a positive association. Note the bimodality in the distributions over the marginal association of input with children's 1ps. (second row, third column) and 3ps. pronouns (fifth row, third column). This bimodality owed to highly divergent posterior predicted associations with input before versus after the groupminded turn. Specifically, before the groupminded turn, children's 1ps. and 3ps. utterance proportions had stronger posterior predicted associations with the input than after the groupminded turn (i.e., the right mode corresponds to the before 3;0 predictions and the left mode to the after 3;0 predictions). This pattern reflected the highly divergent associations with input before versus after the groupminded turn for 1ps. and 3ps. pronouns (Fig. 5, second and fifth rows, fourth column) and, indeed, was reflected in the allotment of 100% of mass over negative values of the marginal interaction term for 1ps. and 3ps. (Fig. 6, second and fifth rows, fourth column). This suggests that children's 1ps. and 3ps. utterance proportions are less positively related to their mothers' after compared to before 3;0. A similar, though less pronounced pattern was found for 2p. and 3pp. pronouns (third and fourth rows, fourth column). The sole exception was for 1pp. pronouns (first row, fourth column), for which evidence of an interaction between the groupminded turn and maternal input was equivocal. Altogether, children's utterance proportions increased as their mothers' utterance proportions increased, especially before the groupminded turn at 3;0. Only the association of children's 1pp. utterance proportions and input was stable across the groupminded turn.

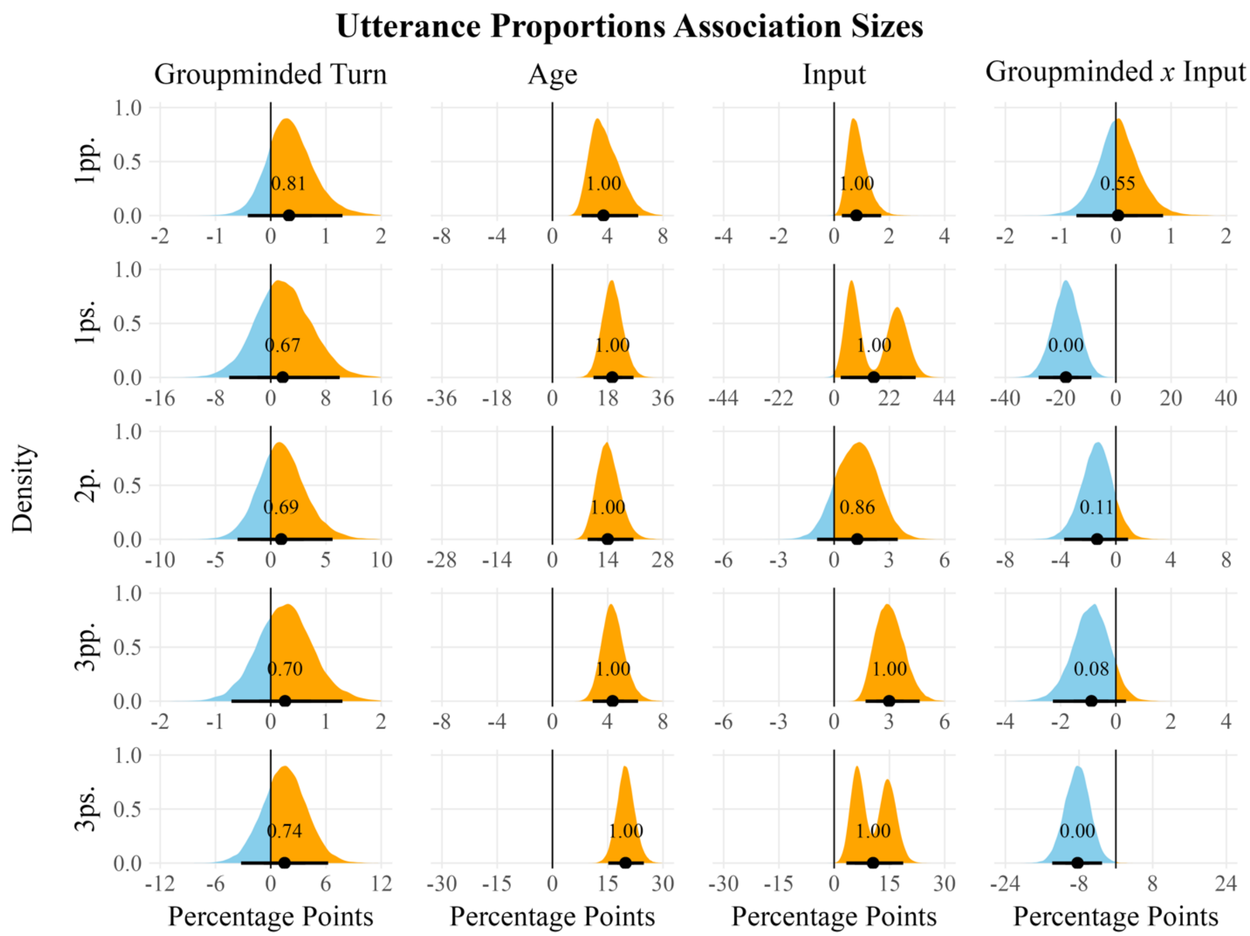

Figure 6. Utterance proportions marginal association sizes computed from the posterior predictions displayed in Figure 5. Organized identically to Fig. 4.

Discussion

The present article built on previous research into children's pronouns (Ibbotson et al., 2018) by investigating the relevance of the groupminded turn for understanding children's pronoun development. Our main prediction was based on shared intentionality theory (Tomasello, 2019). Shared intentionality theory posits that a groupminded shift in social conceptualization during collaboration at 3;0 causes children to begin to conceive of themselves and collaborative partners as part of a cultural group whose members are bound by shared norms and conventions. Reflecting this hypothesis, children were predicted to use proportionally more 1pp. pronouns following the groupminded turn compared to before. Additionally, reflecting the role of input frequency in language development (Ambridge et al., 2015), children were predicted to use proportionally more 1pp. pronouns when mothers used proportionally more 1pp. pronouns. A Bayesian hierarchical generative modeling approach was adopted to investigate these predictions.

Evidence was reported that accorded with the first prediction. Children used proportionally more 1pp. pronouns after compared to before the groupminded shift. Moreover, this was unique to 1pp. pronouns – neither 1ps., 2p., 3pp., nor 3ps. pronouns were associated with groupmindedness; and this was unique to 1pp. pronouns as a proportion of pronouns used. In contrast, there was no reliable association between groupmindedness and any pronoun class as a proportion of total utterances. Rather, pronoun use as a proportion of utterances was more clearly associated with a continuous age parameter, as opposed to the binary groupmindedness parameter. Given the models and data reported in this article, we conclude that 1pp. pronoun proportions are reliably associated with the groupminded shift at 3;0. This conclusion is discussed further, below.

Evidence was reported that accorded with the second prediction. As maternal 1pp. pronoun proportions increased, so did children's. Indeed, this was true for 3pp. and 3ps., too. Interestingly, however, children's 1ps. and 2p. pronoun proportions were unreliably related to input. This differential pattern between 1pp., 3pp., and 3ps., on the one hand, and 1p. and 2p., on the other, is likely related to discourse-pragmatic imperatives concerning felicitous reference (Lambrecht, 1994). When children's mother discusses herself – that is, has a relatively large 1pp. pronoun proportion – children may be unlikely to discuss themselves (i.e., because their mother is topical). In contrast, when children's mother discusses her child – that is, has a relatively large 2p. pronoun proportion – children may be unlikely to discuss their mother (i.e., because child is topical). This is not the case for 1pp., 3pp., or 3ps. – both interlocutors can felicitously use *we*, *they*, *her*, etc. Thus, it is plausible that imperatives concerning felicitous reference account for the documented posterior associations of input with the pronoun classes.

Altogether, these findings suggest that associations of 1pp. pronoun use and groupmindedness exist alongside those of 1pp. pronoun use and input (also, Ibbotson et al., 2018).

We briefly remark on three additional points. First, in contrast to pronoun proportions, the utterance proportions of all five pronoun classes increased with age and input (though, this latter association was less reliable for 2p. pronouns). Regarding age, it may be that children use more pronouns as they age in service of linguistically expressing more complex propositions (see MLU increases in this age range; Miller & Chapman, 1981). Regarding input, we argue that this differential pattern reflects the fact that the two relative frequency measures gauge complementary aspects of language development. Pronoun proportions may track something like children's use of pronouns within discourses (i.e., how children refer to referents within adult-proposed discourse topics). In contrast, utterance proportions may more closely track children's learning of how to use pronouns across discourses (i.e., the discourse topics that children learn to talk about).

Second, the inclusion of a discrete, age-related predictor (i.e., the groupminded turn) and a continuous age predictor in the models allowed us to discern differential patterns of association between these distinct explanatory targets of children's pronoun use. Notably, 1pp., 2p., and 3pp. pronoun proportions nominally increased with age (Fig. 1A). And indeed, all three pronoun classes were positively related to continuous age in the posterior multinomial model. However, only 1pp. pronoun proportions were related to groupmindedness in that model. That is, groupmindedness was reliably associated only with 1pp. pronoun proportions, and not with 2p. and 3pp. pronoun proportions. This suggests that nominally increased use of 1pp., 2p., and 3pp. pronouns with age is associated with distinct explanatory factors – 2p. and 3pp. pronoun proportions are associated with age, whereas those of 1pp. are associated with age and a social-cognitive shift.

Third, there are several limitations to the present study that serve as suggestions for research. Research that more directly relates the emergence of groupmindedness to children's use of pronouns is needed. Implicit throughout the present research was the assumption that children older than 3;0 had undergone the groupminded turn, whereas children younger than 3;0 had not. This is an oversimplification used for computational modeling and reflected our lack of data on nonlinguistic measures of groupmindedness. Thus, future research might directly relate children's performance in nonlinguistic tasks designed to assess the emergence of groupmindedness (e.g., Rakoczy et al., 2008) with their use of pronouns before and after 3;0 (Bates, 1979). Second, fully understanding children's use of pronouns requires a crosslinguistic approach that documents universal and language-specific developmental trajectories. It is plausible that one such universal pattern is the proportional boost in 1pp. use with the emergence of groupmindedness documented here. Third, future work may look to investigate the association of children's pronouns with the interaction of input and continuous age. This interaction was not investigated in the present research because it was not of focal interest. However, it is possible that the strong posterior associations of 1ps. and 3ps. utterance proportions with the interaction of groupmindedness and input, documented here, are, in fact, more closely related to the interaction of continuous age and input. Because this interaction was not investigated in the present research, we cannot rule out this possibility at present. Lastly, reflecting a potential comprehension/production lag, models of groupmindedness that place the shift at ages older than 3;0 (e.g., 3;3 or 3;6) may display a stronger association between groupmindedness and 1pp. pronouns than was shown here. That is, assuming for argument's sake that the groupminded turn occurs at 3;0, it may not be until later than this social-cognitive shift is borne out in children's use of pronouns. This turns on a larger point about the models reported in this article. We strongly support the ethos of Meteyard and Davies (2020), who recommend "liv[ing] with a balance in which data are sacred but analyses are contingent [and in which] we share the data and analysis as transparently as possible [but] do not assume that an analysis as-published will be the last word on the estimation of effects carried in the data," (p. 16). We invite further use of the data reported in this article and complementary modeling approaches.

In conclusion, evidence was reported that a groupminded shift in social conceptualization at 3;0, and input frequency, are associated with children's 1pp. pronouns. Children use more 1pp. pronouns, as a proportion of pronouns, after the groupminded shift than before. It was argued that the groupminded shift expands the set of conceivable plural person referents during collaboration. Consequently, children refer to first-person plural referents proportionally more often.

Data availability statement. All data and code used to perform the analyses in the article will be made publicly available in an Open Science Framework repository.

Appendix

Model	Distr. Par.	Predictor	Estimate	Error	95% HDI
Multinomial	1pp.	Intercept	-0.61	0.09	[-0.78, -0.44]
	1ps.		2.16	0.07	[2.00, 2.30]
	2p.		1.01	0.09	[0.84, 1.19]
	3ps.		1.93	0.07	[1.80, 2.07]
	1pp.	Age	0.31	0.11	[0.10, 0.55]
		Sex	0.13	0.06	[0.01, 0.24]
		Before/After 3;0	-0.14	0.06	[-0.25, -0.03]
		Input (3pp.)	-0.60	0.09	[-0.79, -0.42]
		Input (1pp.)	0.44	0.10	[0.24, 0.65]
		Before/After 3;0 * Input (3pp.)	0.07	0.05	[-0.03, 0.18]
		Before/After 3;0 * Input (1pp.)	-0.05	0.07	[-0.20, 0.09]
	1ps.	Age	-0.68	0.16	[-0.99, -0.36]
		Sex	0.06	0.04	[-0.01, 0.13]
		Before/After 3;0	0.00	0.04	[-0.08, 0.08]
		Input (3pp.)	-0.78	0.08	[-0.95, -0.61]
		Input (1ps.)	0.00	0.06	[-0.13, 0.13]
		Before/After 3;0 * Input (3pp.)	0.01	0.03	[-0.06, 0.07]
		Before/After 3;0 * Input (1ps.)	0.01	0.06	[-0.11, 0.13]
	2p.	Age	-0.08	0.12	[-0.33, 0.17]
		Sex	0.07	0.04	[-0.02, 0.17]
		Before/After 3;0	-0.05	0.05	[-0.15, 0.03]
		Input (3pp.)	-0.79	0.09	[-0.97, -0.60]
		Input (2p.)	-0.11	0.07	[-0.26, 0.04]
		Before/After 3;0 * Input (3pp.)	0.01	0.04	[-0.08, 0.09]
		Before/After 3;0 * Input (2p.)	-0.04	0.07	[-0.18, 0.09]
	3ps.	Age	-0.72	0.17	[-1.05, -0.39]
		Sex	0.01	0.03	[-0.06, 0.08]
		Before/After 3;0	-0.03	0.04	[-0.11, 0.04]
		Input (3pp.)	-0.71	0.08	[-0.87, -0.55]
		Input (3ps.)	0.37	0.06	[0.24, 0.50]
		Before/After 3;0 * Input (3pp.)	0.05	0.03	[-0.01, 0.12]

		Before/After 3;0 * Input (3ps.)	-0.05	0.04	[-0.13, 0.04]
Binomial (1pp.)		Intercept	-4.84	0.14	[-5.12, -4.55]
		Age	1.39	0.16	[1.09, 1.71]
		Sex	0.18	0.06	[0.04, 0.31]
		Before/After 3;0	0.08	0.09	[-0.11, 0.27]
		Input (1pp.)	0.38	0.10	[0.20, 0.59]
		Before/After 3;0 * Input (1pp.)	-0.02	0.07	[-0.17, 0.12]
Binomial (1ps.)		Intercept	-2.02	0.09	[-2.21, -1.84]
		Age	0.60	0.08	[0.43, 0.76]
		Sex	0.05	0.03	[-0.01, 0.12]
		Before/After 3;0	0.00	0.06	[-0.12, 0.13]
		Input (1ps.)	0.51	0.07	[0.37, 0.66]
		Before/After 3;0 * Input (1ps.)	-0.28	0.07	[-0.42, -0.15]
Binomial (2p.)		Intercept	-3.27	0.12	[-3.52, -3.03]
		Age	1.17	0.14	[0.89, 1.45]
		Sex	0.09	0.04	[0.01, 0.18]
		Before/After 3;0	0.04	0.10	[-0.16, 0.25]
		Input (2p.)	0.13	0.06	[0.00, 0.25]
		Before/After 3;0 * Input (2p.)	-0.07	0.05	[-0.19, 0.03]
Binomial (3pp.)		Intercept	-4.43	0.13	[-4.69, -4.17]
		Age	1.15	0.13	[0.89, 1.41]
		Sex	-0.01	0.05	[-0.11, 0.09]
		Before/After 3;0	0.03	0.08	[-0.13, 0.18]
		Input (3pp.)	0.89	0.09	[0.71, 1.07]
		Before/After 3;0 * Input (3pp.)	-0.15	0.07	[-0.30, -0.01]
Binomial (3ps.)		Intercept	-2.38	0.07	[-2.52, -2.22]
		Age	0.78	0.08	[0.62, 0.94]
		Sex	0.01	0.03	[-0.06, 0.07]
		Before/After 3;0	0.02	0.05	[-0.08, 0.12]
		Input (3ps.)	0.45	0.06	[0.34, 0.58]
		Before/After 3;0 * Input (3ps.)	-0.19	0.05	[-0.29, -0.08]

Appendix Table. *Fixed effects marginal posteriors*. “Distr. Par.” is abbreviation of distributional parameter. “Estimate” is median of marginal posterior distribution, “Error” is standard deviation of marginal posterior distribution, "95% HDI" is highest density interval of marginal posterior distribution. Associations with 3pp. input, including the interaction of 3pp. input and groupmindedness, are modeled for each distributional parameter because this encodes the assumption that the association of mothers' 3pp. pronoun proportions with children's 1pp., 1ps., 2p., and 3ps. pronoun proportions differs in size from its association with children's 3pp. pronoun proportions. That is, this modeling choice encodes the assumption that maternal use of 3pp. pronouns is differently related to children's use of 3pp. pronouns than to their use of non-3pp. pronouns. Posterior parameter estimates of the multinomial intercepts can be transformed to the probability scale by multiplying the softmaxed vector of posterior parameter estimates by 100 while holding the multivariate reference category at 0, e.g., $100 * softmax(-0.61, 2.16, 1.01, 0, 1.93) = (2.74, 43.68, 13.83,\ 5.04, 34.71)$. The values on the right-hand side of the equation correspond to the median posterior estimated probability of children using 1pp., 1ps., 2p., 3pp., and 3ps. pronouns, respectively, at the median value of continuous predictors and reference value of categorical predictors. Interpretation of the multinomial non-intercept fixed effects is more complicated; please see, e.g., https://stats.oarc.ucla.edu/stata/output/multinomial-logistic-regression/. Binomial fixed effects interpretation follows standard logistic regression, e.g., exponentiate posterior medians to obtain posterior odds or odds ratios.

References

Ambridge, B., Kidd, E., Rowland, C. F., & Theakston, A. L. (2015). The ubiquity of frequency effects in first language acquisition. *Journal of Child Language*, *42*(2), 239–273. https://doi.org/10.1017/S030500091400049X

Bates, E. (1979). *The Emergence of Symbols: Cognition and Communication in Infancy*. Academic Press.

Bohn, M., Le, K. N., Peloquin, B., Köymen, B., & Frank, M. C. (2020). Children's interpretation of ambiguous pronouns based on prior discourse. *Developmental Science*, e13049. https://doi.org/10.1111/desc.13049

Bürkner, P.-C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, *80*(1), Article 1. https://doi.org/10.18637/jss.v080.i01

Cassidy, S. A., Dimova, R., Giguère, B., Spence, J. R., & Stanley, D. J. (2019). Failing Grade: 89% of Introduction-to-Psychology Textbooks That Define or Explain Statistical Significance Do So Incorrectly. *Advances in Methods and Practices in Psychological Science*, *2*(3), 233–239. https://doi.org/10.1177/2515245919858072

Charney, R. (1980). Speech roles and the development of personal pronouns. *Journal of Child Language*, *7*(3), 509–528. https://doi.org/10.1017/S0305000900002816

Clark, H. H., & Marshall, C. R. (1981). Definite Reference and Mutual Knowledge. In A. K. Joshi, B. L. Webber, & I. A. Sag (Eds.), *Elements of Discourse Understanding* (pp. 10–63). Cambridge University Press.

Comrie, B. (2013). Alignment of Case Marking of Pronouns. In M. S. Dryer & M. Haspelmath (Eds.), *The World Atlas of Language Structures Online*. Max Planck Institute for Evolutionary Anthropology. https://wals.info/chapter/99

Gabry, J., & Mahr, T. (2022). *bayesplot: Plotting for Bayesian Models* (1.10). https://mc-stan.org/bayesplot/

Gabry, J., Simpson, D., Vehtari, A., Betancourt, M., & Gelman, A. (2019). Visualization in Bayesian workflow. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *182*(2), 389–402. https://doi.org/10.1111/rssa.12378

Gelman, A. (2008). Scaling regression inputs by dividing by two standard deviations. *Statistics in Medicine*, *27*(15), 2865–2873. https://doi.org/10.1002/sim.3107

Gelman, A., Carlin, J., Stern, H., Dunson, D., Vehtari, A., & Rubin, D. (2013). *Bayesian Data Analysis* (3rd ed.). CRC Press/Taylor & Francis.

Gelman, A., Hill, J., & Vehtari, A. (2020). *Regression and Other Stories*. Cambridge University Press.

Girouard, P. C., Ricard, M., & Décarie, T. G. (1997). The acquisition of personal pronouns in French-speaking and English-speaking children. *Journal of Child Language*, *24*(2), 311–326. https://doi.org/10.1017/S030500099700305X

Goodman, J. C., Dale, P. S., & Li, P. (2008). Does frequency count? Parental input and the acquisition of vocabulary. *Journal of Child Language*, *35*(3), 515–531. https://doi.org/10.1017/S0305000907008641

Harrison, X. A. (2014). Using observation-level random effects to model overdispersion in count data in ecology and evolution. *PeerJ*, *2*, e616. https://doi.org/10.7717/peerj.616

Hobson, R. P., Lee, A., & Hobson, J. A. (2010). Personal Pronouns and Communicative Engagement in Autism. *Journal of Autism and Developmental Disorders*, *40*(6), 653–664. https://doi.org/10.1007/s10803-009-0910-5

Ibbotson, P., Hartman, R. M., & Björkenstam, K. N. (2018). Frequency filter: An open access tool for analysing language development. *Language, Cognition and Neuroscience*, *33*(10), 1325–1339. https://doi.org/10.1080/23273798.2018.1480788

Kay, M. (2022). *tidybayes: Tidy Data and Geoms for Bayesian Models*. Zenodo. https://doi.org/10.5281/zenodo.5823492

Kirjavainen, M., Theakston, A., & Lieven, E. (2009). Can input explain children's me-for-I errors? *Journal of Child Language*, *36*(5), 1091–1114. https://doi.org/10.1017/S0305000909009350

Kruschke, J. K., & Liddell, T. M. (2018). The Bayesian New Statistics: Hypothesis testing, estimation, meta-analysis, and power analysis from a Bayesian perspective. *Psychonomic Bulletin & Review*, *25*(1), 178–206. https://doi.org/10.3758/s13423-016-1221-4

Lambrecht, K. (1994). *Information structure and sentence form: Topics, focus, and the mental representations of discourse referents* (pp. xvi, 388). Cambridge University Press. https://doi.org/10.1017/CBO9780511620607

Langacker, R. W. (1987). *Foundations of Cognitive Grammar: Theoretical prerequisites: Vol. I*. Stanford University Press.

Langacker, R. W. (2007). Constructing the meanings of personal pronouns. In G. Radden, K.-M. Köpcke, T. Berg, & P. Siemund (Eds.), *Aspects of Meaning Construction* (pp. 171–187). John Benjamins. https://benjamins.com/catalog/z.136.12lan

Lemoine, N. P. (2019). Moving beyond noninformative priors: Why and how to choose weakly informative priors in Bayesian analyses. *Oikos*, *128*(7), 912–928. https://doi.org/10.1111/oik.05985

Lo, S., & Andrews, S. (2015). To transform or not to transform: Using generalized linear mixed models to analyse reaction time data. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01171

MacWhinney, B. (2014). *The CHILDES project: Tools for analyzing talk, Volume II: The database*. Psychology Press.

Matthews, D., Lieven, E., Theakston, A., & Tomasello, M. (2009). Pronoun co-referencing errors: Challenges for generativist and usage-based accounts. *Cognitive Linguistics*, *20*(3), 599–626. https://doi.org/10.1515/COGL.2009.026

Meteyard, L., & Davies, R. A. I. (2020). Best practice guidance for linear mixed-effects models in psychological science. *Journal of Memory and Language*, *112*. https://doi.org/10.1016/j.jml.2020.104092

Miller, J. F., & Chapman, R. S. (1981). The Relation between Age and Mean Length of Utterance in Morphemes. *Journal of Speech, Language, and Hearing Research*, *24*(2), 154–161. https://doi.org/10.1044/jshr.2402.154

Moll, H., Carpenter, M., & Tomasello, M. (2007). Fourteen-month-olds know what others experience only in joint engagement. *Developmental Science*, *10*(6), 826–835. https://doi.org/10.1111/j.1467-7687.2007.00615.x

Oberauer, K. (2022). The Importance of Random Slopes in Mixed Models for Bayesian Hypothesis Testing. *Psychological Science*, *33*(4), 648–665. https://doi.org/10.1177/09567976211046884

Pedersen, T. L. (2022). *patchwork: The Composer of Plots* (1.1.2). https://CRAN.R-project.org/package=patchwork

Piaget, J. (1926). *The language and thought of the child* (pp. xxiii, 246). Harcourt, Brace.

Rakoczy, H., Warneken, F., & Tomasello, M. (2008). The sources of normativity: Young children's awareness of the normative structure of games. *Developmental Psychology*, *44*(3), 875–881.

Ricard, M., Girouard, P. C., & Décarie, T. G. (1999). Personal pronouns and perspective taking in toddlers. *Journal of Child Language*, *26*(3), 681–697. https://doi.org/10.1017/S0305000999003943

Rispoli, M. (1998). Me or my: Two different patterns of pronoun case errors. *Journal of Speech, Language, and Hearing Research*, *41*(2), 385–393. https://doi.org/10.1044/jslhr.4102.385

Rubin, D. B. (1984). Bayesianly Justifiable and Relevant Frequency Calculations for the Applied Statistician. *The Annals of Statistics*, *12*(4), 1151–1172. https://doi.org/10.1214/aos/1176346785

Sanchez, A., Meylan, S. C., Braginsky, M., MacDonald, K. E., Yurovsky, D., & Frank, M. C. (2019). childes-db: A flexible and reproducible interface to the child language data exchange system. *Behavior Research Methods*, *51*(4), 1928–1941. https://doi.org/10.3758/s13428-018-1176-7

Stan Development Team. (2022). *Stan Modeling Language Users Guide and Reference Manual, Version 2.30*. https://mc-stan.org

Team, R. C. & others. (2013). *R: A language and environment for statistical computing*.

Tomasello, M. (2003). *Constructing a Language: A Usage-Based Approach to Child Language Acquisition*. Harvard University Press.

Tomasello, M. (2019). *Becoming Human: A Theory of Ontogeny*. Harvard University Press.

Vasil, J. (2022). A New Look at Young Children's Referential Informativeness. *Perspectives on Psychological Science*. https://doi.org/10.1177/17456916221112072

Vygotsky, L. S. (1962). *Thought and Language* (4th ed.). The MIT Press.

Warneken, F., Chen, F., & Tomasello, M. (2006). Cooperative activities in young children and chimpanzees. *Child Development*, *77*(3), 640–663.

Wasserstein, R. L., Schirm, A. L., & Lazar, N. A. (2019). Moving to a World Beyond “p < 0.05.” *The American Statistician*, *73*(sup1), 1–19. https://doi.org/10.1080/00031305.2019.1583913

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). Welcome to the Tidyverse. *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Winter, B., & Bürkner, P.-C. (2021). Poisson regression for linguists: A tutorial introduction to modelling count data with brms. *Language and Linguistics Compass*, *15*(11), e12439. https://doi.org/10.1111/lnc3.12439