Person distinctions are independent of number: Evidence from artificial language learning experiments

Fang Wang (fwang4@ed.ac.uk)[1] **& Mora Maldonado**[2]
[1]School of Philosophy, Psychology, and Language Sciences, The University of Edinburgh
[2]Departament de Traducció i Ciències del Llenguatge, Universitat Pompeu Fabra

Abstract

Pronominal systems tend to maintain the same person distinctions across number categories. This has been explained by most linguistic theories in which pronominal systems are modeled as a combination of independent person and number features (e.g., Harbour, 2016; Harley and Ritter, 2002). At the same time, person and number features are known to interact asymmetrically, which some have taken to indicate that personal pronouns are not straightforwardly the composition of person and number, but rather categories on their own (e.g., Cysouw, 2009). The main source of evidence for feature-based theories is typological data. In this study, we use an artificial language learning approach to provide complementary behavioral evidence to the question of the independence of person and number in personal pronouns. We test whether learners have a preference for person systems that maintain uniform person distinctions across number categories. Our results suggest that, in the absence of explicit evidence, learners infer the same person distinctions across number categories, regardless of whether number is morphologically transparent or not. Our findings suggest that pronominal systems are most effectively learned as combination of distinct person and number features, rather than as unified categories.

Keywords: person systems; pronouns; number; artificial language learning; extrapolation

Introduction

Person pronominal systems categorize entities based on their role in the context of speech: the speaker (first person), the addressee (second person), and other who doesn't participate in the conversation (third person) (e.g., *I*, *you*, *she* in English). Languages differ in how they map pronominal referents into forms. Some languages use different forms to express different referents, and others use the same form to express different referents (i.e., homophony). For example, English has distinct pronominal forms to refer to the speaker, addressee, and other (a tripartition structure), whereas Damin uses a distinct form to refer to speaker, but the same form to refer to addressee and other (homophony between the second and third person) (Hale & Nash, 1997, p. 248). Despite the variation across pronominal systems in categorizing different referents, pronominal systems tend to maintain the same person distinctions across number categories (e.g., Cysouw, 2009; Harley and Ritter, 2002).[1] That is, if a pronominal system distinguishes between first, second, and third person in the singular, it is also likely to do so in the plural. Feature-based theories of person account for this tendency by modeling pronominal systems as a combination of independent person and number features (e.g., Ackema and Neeleman, 2018; Harbour, 2016; Harley and Ritter, 2002). For example, in Harley and Ritter (2002)'s feature-geometry theory, two independent nodes PARTICIPANT and INDIVIDUATION are posited to represent person and number respectively (as shown in Figure. 1). Person distinctions are made by the person features under the PARTICIPANT node, and number distinctions are made by the features under the INDIVIDUATION node. Abstracting away from the details, singular meanings are expressed when the [Minimal] feature under the INDIVIDUATION node is activated, and plural meanings are expressed when the [Group] feature is activated[2]. Feature-based theories therefore predict uniform person distinctions across number categories.

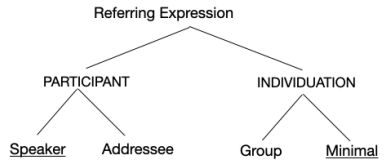

Figure 1: Part of the feature-geometry illustration in Harley and Ritter (2002). The underlined daughter nodes represent the default interpretation of an unmarked organizing node.

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On the other hand, person and number features interact asymmetrically. This is evident in the fact that the meaning of plurality in personal pronouns is not uniform across person categories (e.g., Bhat, 2004; Corbett, 2000; Cysouw, 2009, 2011; Moravcsik, 2003). For example, first-person plural pronouns typically refer to a group including the speaker (but not every member in the group is speaker, a.k.a associative plural), whereas third-person plural pronouns typically refer to a group where every member is other (additive plural). The distinct behaviors of plural personal pronouns across per-

[1]Note that this is different from number distinctions across person categories, which has been shown to exhibit a hierarchy that third person is more likely to lack a number distinction than second person, which in turn is more likely to lack a number distinction than first person (horizontal homophony, see Cysouw, 2009; Saldana and Maldonado, 2024).

[2]There is also a daughter node [Augmented] under [Minimal], which has been posited to express the meaning 'paucal' in some languages. See Harley and Ritter (2002) for a detailed discussion.

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son categories suggest that plural personal pronouns are not straightforwardly compositional. In other words, they are not simply the sum of person and number features, but rather categories on their own (Cysouw, 2009, 2011). For example, Cysouw (2009, 2011) hypothesized eight person/number primitives for the pronominal paradigmatic structure, including three for singular referents and five for groups.[3]

The main source of evidence for theories that argue for independent person and number features is typological data. We aim here to bring behavioral evidence addressing this question by testing whether person and number in personal pronouns are represented independently during language learning. Following Maldonado and Culbertson (2020), the general assumption is that if two systems share the same underlying features, then learners will apply the same distinctions across those systems, rather than assuming different distinctions for each one. This tendency is driven by a very general simplicity bias, according to which, all things being equal, learners prefer simpler systems (e.g., Chater and Vitányi, 2003; Culbertson and Kirby, 2016). Research has shown that in the absence of evidence in the language input, learners tend to extrapolate the known rules to new items or domains, with the likelihood of extrapolation depending on the similarity between the items or domains (e.g., phonology: Cristia et al., 2013; Finley, 2022; lexicon and morphology: Dautriche et al., 2016; Saldana et al., 2022; syntax: Culbertson et al., 2025; Wang et al., 2025; see also discussion in Maldonado and Culbertson, 2020). Applied to the case examined here, if person and number are represented as independent features in personal pronouns and different number categories share the same person features, then learners should tend to assume the same person distinctions for pronominal paradigms in different number categories, as predicted by feature-based theories (e.g., Harley and Ritter, 2002). By contrast, if different pronominal referents are categories of their own, that is, no uniform person distinctions are expected across number categories, no such bias is predicted.

We use an artificial language learning approach to test the hypothesis that learners infer the same person distinctions across number categories. In this study, English-speaking participants are taught one of two possible bipartition structures of singular pronominal paradigms: a speaker-based or a participant-based bipartition (see Figure 2 for language examples: Damin: Hale and Nash (1997), as cited in Harbour, 2016, p. 55; Winnebago: Noyer, 1992; as cited in Harley and Ritter, 2002, p. 512). Participants are then tested on whether they infer the same person contrast when they need to refer to groups, in the plural pronominal paradigm.

[3]The eight person/number primitive are speaker (1), addressee (2), other (3), minimal inclusive (1+2), augmented inclusive (1+2+3), exclusive (1+3), addressee with others (2+3), and others (3+3).

Referent	Speaker bipartition (Damin)		Participant bipartition (Winnebago)	
Speaker	[+speaker]	*n!aa*	[+participant]	*nee*
Addressee	[-speaker]	*n!uu*	[+participant]	*nee*
Other	[-speaker]	*n!uu*	[-participant]	*ʔee*

Figure 2: Examples of pronominal systems with a bipartition structure

Experiment 1

This experiment, including the hypothesis, predictions, and analyses, was preregistered here.

Methods

Design We adopt a Poverty-of-the-stimuli paradigm (or 'extrapolation paradigm') in artificial language learning, in which learners receive partial exposure to a novel language while withholding the critical evidence needed to determine the target structure. At the critical test, learners need to extrapolate from what they have learned to held-out data (Maldonado & Culbertson, 2020, 2022; Wilson, 2006). The design is based on Maldonado and Culbertson (2020), which tested semantic primitives in person and locative systems. Participants are taught a singular pronominal paradigm with either a speaker bipartition (i.e., distinction between speaker and non-speaker) or a participant bipartition (i.e., distinction between participant and non-participant), and are asked to infer a bipartition structure in the plural. As no information of the structure of the pronominal paradigm in the plural is provided, both a speaker bipartition and a participant bipartition in the plural are possible. The pronominal paradigm that learners infer at the critical test will indicate whether they have a preference for a system that keeps uniform person distinctions across number categories.

The experiment has two conditions: the speaker bipartition condition (Condition 1) and the participant bipartition condition (Condition 2). The two conditions differ only on the singular pronominal paradigm taught to participants: Condition 1 instantiates a speaker bipartition (i.e., one form for singular speaker (1sg), and another form for singular addressee (2sg) and singular other (3sg)); Condition 2 instantiates a participant bipartition (i.e., one form for singular speaker (1sg) and singular addressee (2sg), and another form for singular other (3sg)). In both conditions, after learning the singular forms, participants are taught two plural forms: one referring to groups that include speaker and other(s) (1pl) and the other referring to groups that include only others (3pl). No information about the form for groups that include addressee and other(s)(i.e., 2pl) is provided during the training. At the critical test, participants are asked to use one of the two plural forms they have learned to refer to groups that include addressee and other(s) (held-out meaning) (see Figure 3A). Participant's responses in the critical test indicate what bipartition structure they have inferred in the plural. If they use the

form for the 1pl meaning to refer to groups that include addressee, it indicates a participant bipartition (i.e., homophony between first- and second-person plural pronouns); alternatively, if they use the form they learned for the 3pl meaning, it indicates a speaker bipartition (i.e., homophony between the second- and third-person plural pronouns).

	Singular training	Plural training	Extrapolation
Condition 1 (Speaker bipartition)	1sg = form 1 2sg, 3sg = form 2	1pl = form 1-*fu* 3pl = form 2-*fu*	2pl = form 1-*fu*? or form 2-*fu*?
Condition 2 (Participant bipartition)	1sg, 2sg = form 1 3sg = form 2		

(A) Conditions in Experiment 1

	Singular training	Plural training	Extrapolation
Baseline Condition (Tripartition)	1sg = form 1 2sg = form 5 3sg = form 2	1pl = form 3 3pl = form 4	2pl = form 3? or form 4?
Condition 1 (Speaker bipartition)	1sg = form 1 2sg, 3sg = form 2		
Condition 2 (Participant bipartition)	1sg, 2sg = form 1 3sg = form 2		

(B) Conditions in Experiment 2

Figure 3: Design conditions in Experiments 1 and 2.

Our hypothesis is that learners prefer the system that makes the same person distinctions across number categories. We predict that participants in Condition 2 are more likely to infer a participant bipartition for plural pronouns than those in Condition 1.

Materials In order to increase the likelihood of getting an influence of the singular over the plural, number marking was morphologically transparent: plural forms for the first and third person were created by adding the suffix *-fu* to the corresponding singular forms. Singular forms were *bo* and *ga*, and plural forms were *bofu* and *gafu* (e.g., *bo* for singular speaker, and *bofu* for groups that include speaker and other(s)). Forms were randomly mapped into meanings across participants.

Pronouns were used as one-word answers to questions presented in English. Visual stimuli were pictures of a family consisting of three sisters and their parents. Each family member had a clear speech-act role in the conversational context. The two older sisters were always speech act participants (either speaker or addressee). The parents and the third little sister were always others, without participating in the conversation throughout the experiment. The speaker and addressee roles between the two older sisters switched multiple times throughout the experiment to highlight that the novel words vary depending on conversational roles determined by the context. In each trial, the addressee would ask a question like 'Who will be rich?' and the speaker would answer using a pronominal form. The reference of the pronoun was expressed by highlighting either a single family member (for singular person pronominal forms) or a group of family members (for plural person pronominal forms), as exemplified in Figure 4.

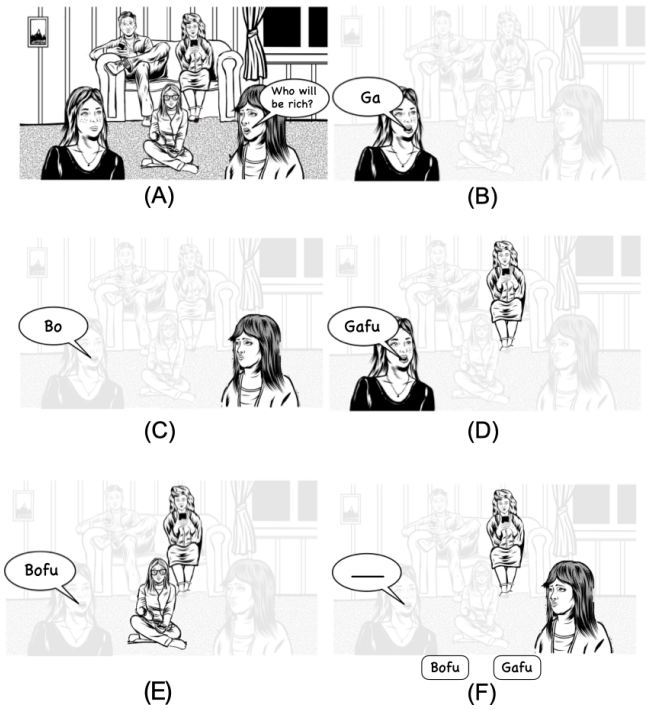

Figure 4: Example trials of Experiment 1. Panels A-E show trials in Condition 1 (speaker bipartition), including an example question (A), responses for 1sg, 2sg, 1pl, and 3pl (B-E), and held-out trial (F). In the held-out trial, participants are asked to select between the two plural forms which one they would use to refer to a group including the addressee and other(s) (2pl meaning).

Procedure The general procedure also followed Maldonado and Culbertson (2020, 2022). Participants were introduced to the family and told they would observe the two older sisters playing a game involving questions about future events, in which one sister asked a question and the other responded using a word from an ancestral language. Participants' task was to infer the meanings of these words. To discourage participants from learning the words as character names, they were instructed that the words functioned like English pronouns. Data quality was ensured with an attention-check question requiring participants to identify the type of words being learned; participants who failed after three attempts were excluded from the experiment.[4]

Participants first learned the two singular forms in a singular training phase (Block 1) and a singular testing phase (Block 2). During training, participants were exposed to both the word and the meaning, indicated by highlighting the referent. Participants then selected the form they had just seen from two options, with feedback provided on each trial. If the participant's response was correct, then the word participant chose became green and also appeared in the speech bubble of the

[4]Responses including any English personal pronouns, or the word "pronoun" or "pronouns" were accepted as correct.

speaker, accompanied by a message saying "Well done!". If the participant's response was incorrect, then the word participant chose became red and the correct word appeared in the speech bubble, shown in green, accompanied by a message saying "Wrong!". There were 9 trials in the singular training phase (3 repetitions per meaning). The testing phase was similar to the training except that no pronominal form would appear in the screen and participants were asked to choose the forms by picking among two options. Feedback was provided for each response. There were 18 trials in the singular testing phase (6 repetitions per meaning).

Participants then learned two plural pronominal forms in a plural training phase (Block 3). The procedure of plural training trials was the same as that of singular training trials, except that participants were asked to select the pronominal form from all four singular and plural forms that they had been taught. The cardinality (i.e., either two or three) of the referent was counterbalanced between first and third plural pronominal forms. There were 6 trials in the plural exposure phase (3 repetitions for each of the two taught plural meanings (i.e., 1pl and 3pl)).

In a combined testing phase (Block 4), participants were tested on all four singular and plural forms using the same procedure as in Block 2, selecting from all four forms with feedback. This block included 32 trials (4 repetitions per singular meaning and 10 per taught plural meaning).

Participants were lastly tested on all of the plural meanings, including the two plural meanings they had learned as well as the held-out meaning (2pl) (Block 5, critical testing phase). The procedure of the trials was the same as that of the plural testing trials in Block 4, except that participants were asked to select a pronominal form from the two plural forms and no feedback was provided. There were 14 testing trials (4 repetitions per taught plural meaning and 6 repetitions of the held-out meaning).

In each block, speaker and addressee roles switched once, with explicit instruction, to reinforce the context-dependent interpretation of the pronominal forms and prevent character-based strategies. After the experiment, participants were asked weather they spoke other languages besides English.

Participants A total of 143 English-speaking adults (Condition 1: 66; Condition 2: 77) were recruited via Prolific. To confirm that participants were native English speakers, we used four screener criteria on Prolific: 1) First language: English; 2) English-speaking monolingual: I only know English; 3) Were you raised monolingual? I was raised with my native language only; 4) Bilingual: none just my native language. Participants who completed the whole experiment, with the accuracy no lower than 60% for each singular meaning across Blocks 2 and 4 and accuracy no lower than 57% for each taught plural meaning across Blocks 4 and 5 were included in the analysis (Condition 1: 35; Condition 2: 36). [5] No participants reported speaking a language with a bipartition pronominal system. Participants were paid £3 for their participation, which lasted approximately 18 minutes.

Results

Recall that participants were taught two plural forms, with one referring to a group including the speaker and other(s) (1pl), and the other referring to a group including only others (3pl). At the critical test, participants were asked to select between the two plural forms to refer to a group including addressee and other(s) (2pl). We are interested in whether participants tend to extrapolate the pronominal paradigm they were taught in the singular into the plural. Figure 5A shows the proportion of trials that participant chose the form for 1pl meaning for the held-out 2pl meaning (i.e., matching a participant bipartition in the plural) as a function of Condition.

We ran a logistic mixed-effects regression model predicting the responses in held-out trials. The dependent variable was whether participant's response matched the participant bipartition or not. The independent variable was Condition (sum-coded). By-participant random intercepts were included. The model revealed that participants in Condition 2 were more likely to choose the form that matched the participant bipartition than those in Condition 1 ($\beta = 3.27$, $z = 6.36$, $p < 0.001$).

Discussion

English speakers first learned a singular pronominal paradigm with a bipartition structure, either a speaker bipartition (where the second and the third person were expressed using a single homophonous form) or a participant bipartition (where the first and second person were expressed using a single homophonous form), and tested whether they tended to infer the same contrast when they needed to refer to groups. Our results indicate that participants who are taught a participant bipartition in the singular are more likely to infer a participant bipartition in the plural compared to those who are taught a speaker bipartition in the singular. That is, the singular training had an impact on the inference about the plural. These findings confirm our hypothesis, indicating that learners tend to keep the same person distinctions across number categories. This is in line with the prediction of feature-based theories, in which person and number are posited as independent features (e.g., Harbour, 2016; Harley and Ritter, 2002).

Two caveats are worth noting. First, English learners are known to show a preference for speaker-based pronominal

[5] This criterion was different from our preregistration because applying the preregistered exclusions would have resulted in a very large number of exclusions. As some participants appeared to learn the language at the later stages in the experiment, we instead set the threshold based on participants' accuracy across Blocks 2 and 4 (for singular meanings) and across Blocks 4 and 5 (for the two taught plural meanings). Note that this change does not directly impact in our analysis, which are on the held-out trials in Block 5. The number of resulting exclusions was still high but aligned with exclusions on previous experiments using this paradigm (Maldonado & Culbertson, 2022).

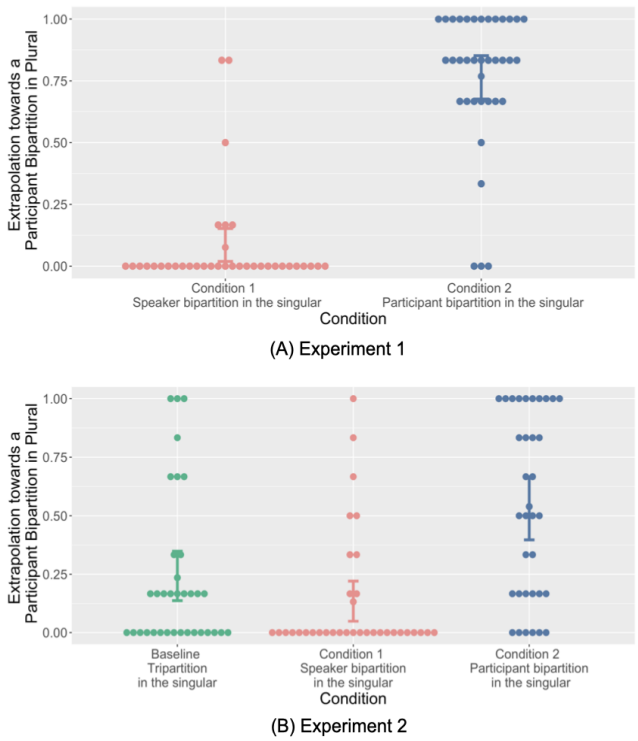

Figure 5: Proportion of responses choosing the form for 1pl meaning to express the held-out 2pl meaning (i.e., a participant bipartition) in Experiments 1 (A, in which number is morphologically transparent) and 2 (B, in which there is no transparent morphological relation between the singular and plural forms). Dots indicate individual participants' means; error bars indicate 95% bootstrapped confidence intervals around the mean.

systems (Maldonado & Culbertson, 2020, 2022; Maldonado et al., 2023; Zaslavsky et al., 2021). This suggests that our results may not be symmetric across conditions: participants in Condition 2 may be generalizing the same person distinction across number categories, whereas participants in Condition 1 may simply be following their baseline preference.

Second, in this experiment, number was morphologically fully transparent: the two plural forms were derived from the two singular forms by adding the same suffix. Such a design is likely to lead participants to perceive the suffix as an inflection-like plural marker that adds plurality to the singular forms.[6] Given that inflection tends to preserve the core lexical meaning of the word it applies to (e.g., Aronoff and Fudeman, 2022; Baerman, 2015; Stump, 1998), this clear morphological compositionality might cause participants to keep the meanings of the singular forms and directly add the plural suffix to refer to groups. It thus remains uncertain whether the pattern of generalization persists when the singular-plural morphology is not transparent.

To address these questions, we conducted Experiment 2.

Experiment 2

In Experiment 2, we tested whether learners keep the same person distinction between the singular and the plural when there is no transparent morphological relation between the singular and plural person pronominal forms. Preregistration of Experiment 2 can be found here.

Design The design of Experiment 2 is similar to that of Experiment 1, differing only in the meaning–form mapping of the pronominal forms. Here, each person–number combination is mapped onto a distinct lexical item, so there is no way to directly interpret plural forms as compositionally related to the singular. The only difference between singular and plural pronouns is that the latter are longer. Moreover, in order to measure the relative preference for a person bipartition in the plural when there is no such bipartition in the singular, Experiment 2 also includes a Baseline Condition. In the Baseline Condition, participants are taught three different singular pronouns, similar to the distinctions they have in English. Specifically, participants are taught a form referring to the speaker (1sg), a form referring to the addressee (2sg), and a form referring to the other (3sg). The design of Experiment 2 is shown in Figure 3B.

Materials For the two critical conditions (i.e., Conditions 1 and 2), the two singular pronominal forms were the same as those in Experiment 1 (i.e., *ga* and *bo*). The two plural pronominal forms were changed into *tevo*, and *zuki*. To ensure that there is no morphological similarity between singular and plural forms, *ga* was always paired with *tevo* and *bo* with *zuki* (e.g., *ga* refers to the speaker, and *tevo* refers to a group including the speaker and other(s)). For Baseline Condition, one more pair was added: *di* (a singular pronominal form) and *wosa* (a plural pronominal form). As in Experiment 1, the form-meaning mapping was randomized across participants.

The visual stimuli were the same as in Experiment 1, except that the father in the scene was changed into an aunt to discourage participants from thinking about irrelevant information of gender and thereby improve learning.

Procedure The procedure in the two critical conditions in Experiment 2 was the same as in Experiment 1. The procedure in Baseline Condition was the same as in the two critical conditions except the options provided in the plural training phase (Block 3) and the combined testing phase (Block 4). In the plural training phase of Baseline Condition (Block 3), participants were asked to selected what they had seen from two plural forms. This was done with regard to keeping the singular and plural separate given that the singular is not expect to have an influence on the plural. With the same consideration, in the combined testing phase in Baseline Condition (Block 4), participants were asked to select one form from all five

[6] Although English personal pronouns lack transparent number morphology, English count nouns do have plural markers. English speakers therefore have experience with inflectional plural marking.

pronominal forms they had learned (the first three were singular pronominal forms and the last two were plural pronominal forms, with the specific order randomized across participants and kept constant within participants).

Participants A total of 230 English-speaking adults (Baseline Condition: 75; Condition 1: 81; Condition 2: 73; one participant's data were not received due to technical issues) were recruited via Prolific. We used the same Prolific screeners as in Experiment 1. Participants who didn't meet the accuracy threshold (which was the same as that in Experiment 1) were excluded from data analysis (Baseline Condition: 41; Condition 1: 47; Condition 2: 39). This resulted in the analysis of 102 participants in total (Baseline Condition: 34; Condition 1: 34; Condition 2: 34).

Results Figure 5B shows, by condition, the proportion of trials in which participants selected the 1pl form for the held-out 2pl meaning (i.e., responses consistent with a participant-based bipartition in the plural).

We ran a logistic mixed-effects regression model predicting whether responses matched the participant bipartition by Condition (treatment-coded, Baseline Condition as reference). We used by-participant random intercepts. The model revealed that the log-odds of inferring a participant bipartition in the plural in Baseline Condition were significantly below chance level (β = -2.55, z = -3.70, $p < 0.001$). The likelihood that participants chose the form that matched the participant bipartition in Condition 2 (a participant bipartition in the singular) was significantly higher than those in Baseline Condition (β = 2.99, z = 3.21, $p < 0.005$). Participants in Condition 1 (a speaker bipartition in the singular) were numerically less likely to extrapolate a participant bipartition in the plural than those in Baseline Condition, but the difference is not significant (β = -1.79, z = -1.91, p = 0.056).

Discussion The main goal of Experiment 2 was to test whether learners infer the same person distinction across number categories when number is expressed non-compositionally. Participants were taught either a speaker bipartition or a participant bipartition in the singular, and tested on whether they inferred the same person contrast when they needed to refer to groups. Moreover, there was also a Baseline where participants were taught a tripartition in the singular, which allowed us to measure the relative preference for a participant bipartition in the plural when there was no such bipartition in the singular.

Our results first indicate that, in the absence of any training on a singular bipartitition, participants tend to infer a speaker bipartition rather than a participant bipartition in the plural. This replicates results from previous experiments showing a strong bias toward a speaker-based person bipartition (Maldonado & Culbertson, 2020, 2022; Zaslavsky et al., 2021).

Importantly, participants in Condition 2 are more likely to infer a participant bipartition in the plural than those in the Baseline. This means that participants in Condition 2 are over-riding their default preference when they extrapolate the participant bipartition in the plural. Moreover, because participants have no direct way to interpret the plural forms as compositionally derived from the corresponding singular forms (in fact, the corresponding singular pronominal forms and plural pronominal forms share no similarity), this tendency cannot be driven by any morphological similarity of the forms across the two domains. Instead, it suggests that learners tend to infer the same person distinctions across the singular and plural categories.

Participants in Condition 1 (trained on a speaker bipartition) are not less likely to infer a participant bipartition in the plural compared to those in the Baseline; however, this may be due to a floor effect since the preference for a participant bipartition in the Baseline is already quite weak.[7] This asymmetry of the pre-training effects between the two bipartition structures also replicates the results in Maldonado and Culbertson (2020).

Taken together, results in Experiment 2 provide clear evidence that participants infer the same person distinctions across number categories even when number is expressed non-transparently. This suggests that pronominal systems are most effectively learned as the combination of distinct person and number features, rather than as unified categories. The results support the hypothesis of feature-based theories in which person and number are represented as distinct features.

Conclusion

Typological evidence suggests that pronominal systems tend to make the same person distinctions across number categories. This tendency has been explained by feature-based theories, which represent person and number as distinct features that interact in a systematic and compositional way. At the same time, there are also asymmetric interactions between person and number in pronominal systems, leading to the formation of hypotheses that posit them as different categories.

Here, we tested a key prediction of feature-based theories by assessing whether participants tend to assume the same person distinctions in different number categories when learning a novel language. We found that learners infer the same person distinctions across number categories, regardless of whether number is morphologically transparent or not. Our findings suggest that pronominal systems are most effectively learned as combination of person and number features, providing new behavioral evidence in support of feature-based theories.

[7] A bias for speaker-based distinctions is observed in speakers with different language backgrounds in both linguistic and non-linguistic categorization tasks (Maldonado & Culbertson, 2022; Maldonado et al., 2023), and it's likely to be a general conceptual bias, resulting from the importance of ego. However, it could be that speakers of languages with pronominal systems where the feature [speaker] has a less prominent role (e.g., participant-bipartitions like Winnebago) show different preference patterns. In particular, a potential difference between the Baseline and Condition 1 might be more evident in speakers of these languages.

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