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Probing the Impact of Exposure to Diversity on Infants' Social Categorization

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Humans learn about the world through inductive reasoning, generalizing information about an individual to others in the category. Indeed, by infancy, monolingual children expect people who speak the same language (but not people who speak different languages) to be similar in their food preferences (Liberman et al., 2016). Here, we ask whether infants who are exposed to linguistic diversity are more willing to generalize information even across language-group lines. To test this, we ran an inductive inference task and collected data on exposure to linguistic diversity at the interpersonal and neighborhood levels. Infants with more linguistically diverse social networks were more likely to generalize a food preference across speakers of different languages. However, this relationship was not seen for neighborhood diversity. We discuss implications of this work on understanding the development of bias and its malleability based on early social experiences.

Public Significance Statement
The tendency to divide the world into groups begins early in life: Even infants think people from the same group may share important similarities. Here, we find that early social expectations may be more flexible for infants who are exposed to diversity. In particular, infants with more linguistically diverse social networks were more likely to generalize information across language-group lines, suggesting they may form less rigid social group boundaries.

Keywords: infancy, diversity, social categorization, bilingualism

Categorization can help people learn rapidly about the world around them: Rather than separately acquiring information about each individual, people make inductive inferences in which they generalize information about one item to other members of the category (e.g., Gelman & Markman, 1986). Indeed, preschoolers make inductive inferences when reasoning about artifacts, natural kind categories (e.g., Gelman & Markman, 1987), and about social categories (e.g., gender; Pillow et al., 2015). Interestingly, the development of this skill begins early in life: 13-month-olds expect that members of a category will be similar to one another (e.g., Graham et al., 2004). Recent research finds a similar pattern for social categorization in the first year of life: Monolingual infants generalize a food preference across speakers of the same language, but not across people who speak different languages (Liberman et al., 2016; see also Scott & Henderson, 2013). Here we investigate how exposure to linguistic diversity impacts infants' learning about the boundaries of language-based social categories. Specifically, we hypothesize that infants with greater exposure to linguistic diversity will have less strictly bounded language-based social categories and therefore will be more likely to generalize information across speakers of different languages.

The idea that exposure to people outside of one's group could have implications for the development of bias is foundational in social psychology. Indeed, decades of work on the contact hypothesis have shown that out-group contact is related to lower prejudice (Pettigrew & Tropp, 2006). Though there are variations within studies on contact, the key principle is that positive contact with a person (or people) from a particular out-group will reduce prejudice against other people in that group. For example, White students assigned to live with Black roommates demonstrated increased positive attitudes toward Black people which were not seen for White students who had been paired with same-race roommates (Shook & Fazio, 2008). Contact has similar effects in childhood: German children in diverse schools who befriend Turkish children later show fewer negative attitudes toward Turkish people as a group (Feddes et al., 2009). The vast majority of work on contact focuses on such

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attitudinal variables: increased (positive) contact with an out-group increases liking of members of that group. Importantly, research on bias suggests that attitudes are not the whole story: The affective component of bias (prejudice) may operate somewhat independently of the more cognitive components (stereotyping; see Amodio & Devine, 2006). Therefore, it is important to understand whether contact plays a similarly positive role for changing the more cognitive aspects of bias.

The cognitive aspect we investigate is infants' inductive inferences, and the tendency to restrict generalizing learned information based on group membership. One possibility is that contact will not influence inductive inferences. For example, the mechanism by which contact increases liking of the out-group may be familiarity. "Mere" familiarity can increase liking, even apart from any social or interactive contexts (e.g., Zajonc, 2001). Therefore, having regular contact with an other-race roommate, for instance, may make that other race more familiar, leading to increased liking and more positive attitudes. If familiarity is the main mechanism, contact may not have the same effect on more cognitive features of bias. For example, people can make inductive inferences about social categories regardless of familiarity. That is, a participant who is equally unfamiliar with German and Japanese cultures might nevertheless expect two Germans to be more likely to practice the same religion than for a German and a Japanese person to have the same religious background, however, having regular interactions with people from different groups could allow a person to notice cross-group similarities, in which case contact could also impact inductive inferences. In fact, children living in a diverse state (Hawaii) show fewer increases in out-group stereotyping with age compared to children living in a homogenous state (Massachusetts; Pauker et al., 2016), suggesting contact could shift inductive inferences. Here, we test whether exposure to (linguistic) diversity leads infants to be more willing to generalize a property (food preference) across (language-based) group lines.

Although we are interested in inductive generalization broadly, we chose to focus on infants' generalization of food preferences. We did so for a few reasons. First, a significant amount of previous work has demonstrated that food preferences are linked to culture even in the first year of life: Infants prefer to eat a food eaten by someone in their own group (Shutts et al., 2009), and expect people in the same group to share food preferences (Liberman et al., 2016). Second, infants may have different cognitive mechanisms for reasoning about food compared to other objects. For example, whereas infants tend to view preferences for objects as individual (and do not generalize object preferences from one person to another: see Buresh & Woodward, 2007), they may view food preferences as more generalizable (Wertz & Wynn, 2014), particularly among people who are members of the same social group (Liberman et al., 2016; Pronovost & Scott, 2021). Third, past work has shown that the connection between language, culture, and food emerges early in life (see, e.g., DeJesus et al., 2019; Liberman et al., 2016; Weatherhead et al., 2022), suggesting that studying the generalization of food preferences across language-group lines might be the most fruitful test case of our general question of interest.

We chose to focus on language-based groups for a couple of reasons. First, monolingual infants see language as socially meaningful. For example, newborns show preferences to listen to their parents' native language (Mehler et al., 1988), and 10-month-olds prefer to interact with native speakers (Kinzler et al., 2009). Indeed, infants raised in monolingual households expect people who speak the same language to be more likely to affiliate than people who speak different languages (Liberman et al., 2017a), and expect people who speak the same language to be similar (e.g., Liberman et al., 2016). Second, infants vary widely in their own language experiences such that children's exposure to different languages can range from almost purely monolingual exposure with only incidental exposure to other languages via media (Kuppens, 2010), to being raised fully bilingual or multilingual (Bialystok, 2020). Therefore, it should be possible to test whether these individual differences in exposure to linguistic diversity impact learning from and about people who speak different languages.

We focus on two types of contact with linguistic diversity: interpersonal diversity and neighborhood diversity. Each of these types of contact has been shown to be important for children's social cognition and social learning. For example, children with interpersonal contact with Spanish speakers (due to participation in a bilingual class) more positively evaluated Latinx children on a variety of characteristics (Wright & Tropp, 2005). And, toddlers in more linguistically diverse neighborhoods were more willing to imitate a Spanish speaker (Howard et al., 2014).

Interestingly, in the latter case, the participants were not actively learning any non-English languages, suggesting that exposure to multiple languages, rather than bilingualism, might be driving the effects. Indeed, children who are regularly exposed to multiple languages (but only speak English) show similar perspective-taking benefits as bilingual children (Fan et al., 2015; Liberman et al., 2017b), suggesting multilingual exposure may impact social cognition. Therefore, rather than conceptualizing infants as belonging to two groups (monolingual vs. bilingual), we investigate language exposure as a continuum. To measure interpersonal exposure we updated the Language and Social Background Questionnaire (LSBQ; Anderson et al., 2018), which provides a continuous score based on the extent and proficiency of language use at home and socially. To measure neighborhood diversity, we use data from the U.S. Census (U.S. Census Bureau, 2020) which provides a continuous measure of the proportion of households in the zip code in which there were non-English speakers. For both measures, we predict that infants with more exposure to linguistic diversity will be more likely to generalize a food preference across speakers of different languages (e.g., be more likely to expect an English speaker and a Spanish speaker to agree).

Method

Transparency and Openness

All relevant materials are available on Open Science Framework (OSF) at https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099 (Immel & Liberman, 2023). Materials include stimuli used in the study, our preregistration plan, all deidentified data, and analysis code. Subjects' videos are not posted as they are not deidentified and parents did not consent to such sharing for this study.

Participants

Ninety-six, 8- to 14-month-old infants ($M_{age} = 9.21$ months; range = 7.82–14.26 months), participated. We preregistered this age range (see https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099) based on the fact that previous studies on social expectation based on food choice have shown consistent

results between 5 and 18 months (e.g., Liberman et al., 2014, 2016, 2021; Wertz & Wynn, 2014), leading us to expect all infants within the age range to show similar patterns. Although the age range is somewhat larger than may be typical for an infancy study, recruiting this wider age range allowed us to test a larger (well-powered) sample. Because our preregistration did not include testing for age effects, the results listed in the sample do not test for age effects. Follow-up analyses (based on reviewer comments) did investigate age as an additional predictor variable, and all led to the same conclusions as reported here (see the additional online materials at https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099 for full analyses with age).

Parents completed a demographic survey with questions about their infants' sex and racial background (entered in free response boxes). Based on these responses, the sample included infants who were female ($n = 53$) and male ($n = 43$), and infants who were White ($n = 64$), Multiracial ($n = 15$), Hispanic/Latino ($n = 10$), Asian ($n = 2$), and Black ($n = 1$), with one parent opting to not respond. Additionally, 87.5% of participants had one or more parent with a college degree. Ten additional participants participated but were not included in analyses due to fussiness ($n = 2$), experimenter error ($n = 6$), and missing data ($n = 2$). Based on the timing of data collection (July 2019–November 2022), some infants were tested before the COVID-19 lockdown ($n = 65$), and some were tested after the lockdown ($n = 31$). However, we did not see an effect of timing on our main dependent measure, infants' looking times to test trials, $F(1, 94) = 0.10$, $p = .755$, or on our main predictor variable, interpersonal exposure to linguistic diversity scores, LSBQ, $F(1, 92) = 0.32$, $p = .575$.

Interpersonal Exposure to Linguistic Diversity

A parent or legal guardian filled out a modified version of the LSBQ (Anderson et al., 2018). Parents reported their child's exposure to one or more languages across different categories such as in the home (e.g., with relatives, siblings, and each parent), and in social and community settings (e.g., in school, out shopping, and with neighbors). We modified the survey to be applicable to infant participants by updating questions (e.g., asking about a babysitter rather than a roommate) and removing irrelevant questions (e.g., those regarding speaking and writing). All modifications were made a priori and can be found on the OSF page (https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099).

Scores were calculated using a calculator designed by Anderson et al. (2018) with higher scores indicating more exposure to a second language. Scores ranged from −3.21 to 7.37 ($M = 0.20$; $SD = 2.45$). Scores below zero indicate the least amount of exposure to non-English languages, thus participants with negative scores would traditionally be considered "monolingual." Continuous scores allow researchers to look at variability in exposure among populations that would be described both as "monolingual" and "bilingual."[1]

Neighborhood Exposure to Linguistic Diversity

Parent-provided zip codes were used to calculate neighborhood linguistic diversity from U.S. Census data (U.S. Census Bureau, 2020) which provides the percentage of households in each zip code that speak English, Spanish, European languages, Asian languages, and "Other" languages. Because we were interested in exposure to linguistic diversity, we summed the proportions of households using any non-English languages in the zip code (range = 0.19–0.44; $M = 0.34$; $SD = 0.08$).

Generalization Task

To measure social categorization, we replicated methods used to test infants' inductive generalization (Liberman et al., 2016). In the task, infants were randomly assigned to one of two conditions: same language (both actors spoke English) or different languages (one actor spoke English and one spoke Spanish). Because actors were both native bilinguals, all infants saw the same two actors (varying only in whether they were presented as speaking English or Spanish). To introduce the language of the actors, infants watched three trials in which the actors told short, generic stories. Then, infants saw three trials in which one of the actors expressed her preference for one of two foods (Bowl A) by saying, "Oooo!" in a positive tone after a bite (see Figure 1). Finally, during six trials, the second actor alternated between actively disagreeing with the first actor by disliking the previously liked food (Bowl A), or by disliking the other food (Bowl B). Dislike was expressed by frowning and saying, "Ew!." At the end of the event, the video paused on a still screen in which the actor looked at the bowl.

Looking time was coded to all familiarization and test trials. Timing started when the motion on the video ended and stopped when the infant looked away from the screen for two consecutive seconds, or when 30 s had elapsed. The live coder was not aware of which bowl (A or B) the actor was eating from. A second coder recoded all the infants from the video and agreed with the initial coder on 98.03% of trials. No subject had more than one test trial with a disagreement between the two coders. On trials where there was disagreement between the two coders on one or two trials, the time from the initial experimenter was used for analyses.

We predicted that greater exposure to linguistic diversity would lead infants to be more likely to generalize a food preference, even across group lines. Therefore, we predicted that in the different languages condition, more exposure to linguistic diversity would lead infants to find disagreement unexpected (indicated by greater proportion of looking to Bowl A test trials). Importantly, we did not expect exposure to diversity to change expectations in the same-language condition (though see Henderson & Scott, 2015 for a counterexample). Thus, our primary prediction was an interaction between exposure to diversity and condition on infants' looking times to the test trials. The study was approved by the IRB at the University of California Santa Barbara (protocol 2-22-0371). Prior to collecting data, the study methods and analysis plan were preregistered on the OSF (https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099).

Results

Before investigating our main question of interest about the impact of exposure to diversity on infants' patterns of generalization, we were interested in confirming that all other measures were similar

[1] We also asked parents to categorize their own infant's language exposure by choosing whether their child was monolingual, exposed to another language, bilingual, or multilingual. Parent report on the categorical measure was related to LSBQ scores (higher LSBQ scores for bilingual and multilingual infants than monolingual infants), but LSBQ was more variable and provides a more nuanced measure.

Figure 1
Study Procedure for Generalization Task

Note. Infants were randomly assigned to one of two conditions where they heard the two actors speak in the same or different languages. During the familiarization trials, Actor 1 liked Bowl A. In the test trials, Actor 2 actively disagreed with Actor 1 by disliking Bowl A or disliking the previously uneaten food from Bowl B. See the online article for the color version of this figure.

across our conditions. Indeed, infants in the same-language condition and different languages condition did not vary significantly in terms of LSBQ scores or general attention (e.g., looking times to the introduction phase, the familiarization phase, or the test phase overall; see Table 1 for means, standard deviations, ranges, and comparisons). Therefore, differences by condition cannot be driving the main pattern of results.

Our main question of interest was whether infants varied in their willingness to generalize a food preference across group lines, and whether this variability was predicted by exposure to linguistic diversity. If infants generalize the food preference, they should look longer when the second actor actively disagrees with the first. Therefore, our primary outcome variable was the proportion of looking to disagreement (Bowl A) test trials which was calculated as looking to Bowl A trials/(looking to Bowl A + Bowl B trials).

We first investigated the impact of exposure to interpersonal linguistic diversity using a linear regression with proportion score as the outcome variable. In addition to our primary predictor of interest (the interaction between condition and LSBQ score), in line with our preregistered plan,[2] we also included household income (measured on a 9-point scale from 1 = *<$15,000* to 9 = *>$150,000*) as a control variable. In line with our predictions, there was a significant

[2] For both interpersonal diversity and neighborhood diversity similar patterns are seen when the control variables (e.g., regarding socioeconomic status) are not included in the model. We included them based on our preregistered plan and in particular since diverse neighborhood may have also been more likely to be denser and less wealthy than nondiverse neighborhoods. Additionally, as noted in the participants section, findings remain unchanged if age is included in the models as an additional predictor variable.

Table 1
Mean, Standard Deviation, and Range of All Measures by Condition

Study portion	Same languages		Different languages		Comparison	
	M (*SD*)	Range (min–max)	*M* (*SD*)	Range (min–max)	*F*	*p*
LSBQ	−0.44 (2.20)	−3.10 to 7.25	0.62 (2.63)	−3.21 to 7.37	2.78	.098
Average attention per introduction trial (seconds)	20.10 (5.84)	3.84–30.05	20.28 (5.47)	8.37–30.97	0.00	.954
Average attention per familiarization trial (seconds)	9.74 (5.85)	1.43–30.00	10.93 (5.19)	2.81–22.93	1.11	.296
Average attention per test trial (seconds)	6.46 (3.60)	2.23–22.39	6.10 (2.94)	2.27–18.33	0.277	.600
Attention to test trials (proportion)	0.51 (0.15)	0.19–0.81	0.49 (0.12)	0.26–0.74	0.45	.506

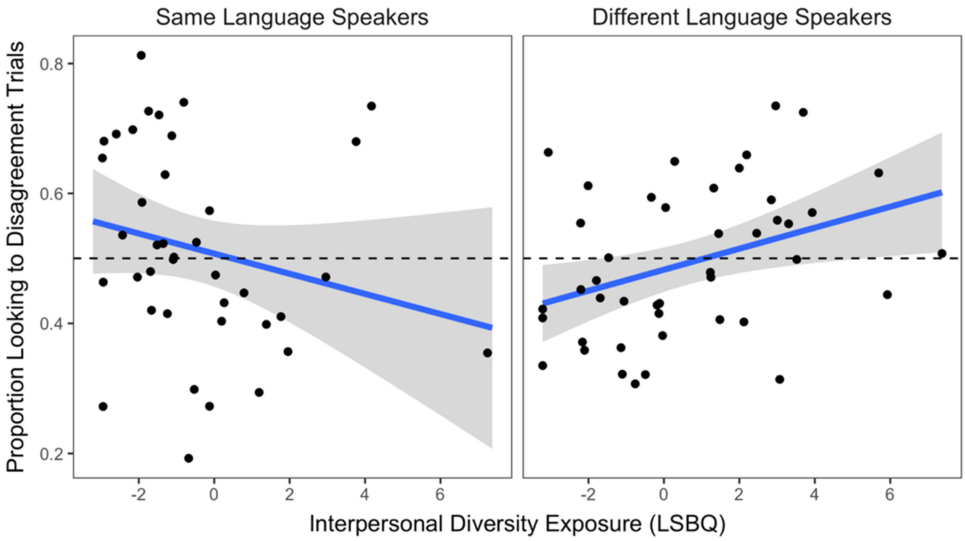
Note. LSBQ = Language and Social Background Questionnaire; min = minimum; max = maximum; Proportion = looking to Bowl A trials/(looking to Bowl A + Bowl B trials).

interaction between condition and LSBQ score ($t = 2.68$, $p = .009$, $OR = 1.03$, 95% CI [0.01, 0.06]); see Figure 2). No other effects were significant ($ps > .124$). Thus, the impact of exposure to linguistic diversity was different depending on the condition. To test whether this difference was in the predicted direction (i.e., no effect in the same-language condition but a positive effect of exposure to diversity in the different languages condition), we next evaluated each condition independently by running two separate linear regressions (one for each condition) predicting the proportion of looking to disagreement with LBSQ score and household income as predictors. As predicted, in the same-language condition there was no significant effect of LBSQ score ($t = -1.14$, $p = .174$) or household income ($t = -0.44$, $p = .665$), suggesting exposure to linguistic diversity did not impact infants' expectations about same-language speakers. However, in the different languages condition, there was a significant effect of LBSQ score ($t = 2.77$, $p = .008$, $OR = 1.02$, 95% CI [0.01, 0.58]), but no effect of household income ($t = 0.46$, $p = .645$). The effect of LSBQ indicated that in the different languages condition, infants with more exposure to linguistic diversity were more likely to generalize a food preference across linguistic group lines.

Next, we asked whether a similar pattern was seen for neighborhood diversity. We again ran a linear regression model with proportion score as the outcome variable, with the interaction between condition and neighborhood diversity as the main predictor of interest. In line with our preregistrations, we also included median household income in the zip code, and zip code population density as predictor variables. We did not find a significant interaction between condition and neighborhood linguistic diversity ($t = 0.40$, $p = .689$), or a main effect of neighborhood linguistic diversity ($t = -0.85$, $p = .396$; see Figure 3). No other effects were significant ($ps > .108$). Therefore, at least in this sample, exposure to linguistic diversity at the neighborhood level was not related to expectations about whether preferences would generalize.

Interestingly, the results for interpersonal exposure to linguistic diversity were best described with the continuous measure of the

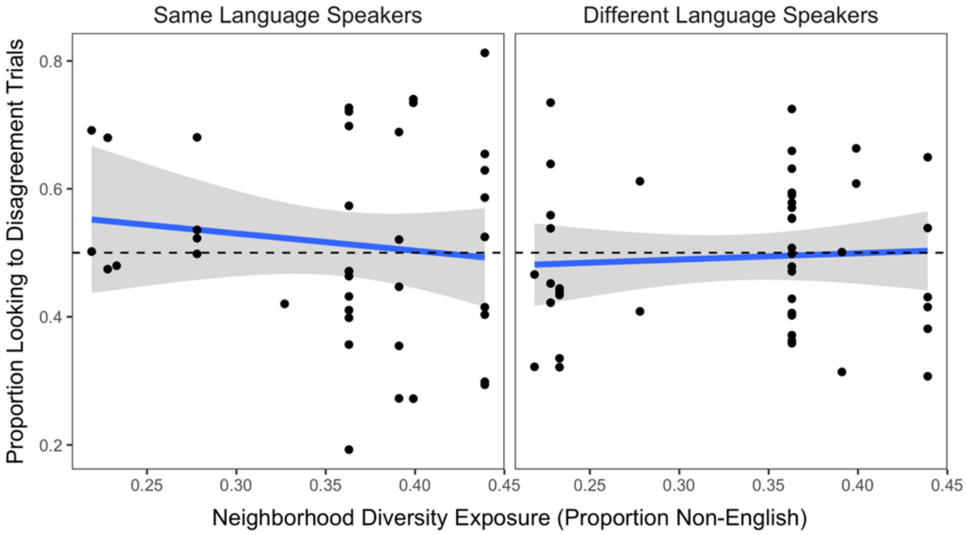
Figure 2
Infants' Proportion Looking to Disagreement Trials Related to Interpersonal Diversity Exposure



Note. The panel on the left depicts data from infants in the same language condition and the panel on the right depicts data from infants in the different languages condition. Plots show the relationship between the proportion of infants' looking to disagreement and LSBQ scores. LSBQ = Language and Social Background Questionnaire. See the online article for the color version of this figure.

Figure 3

Infants' Proportion Looking to Disagreement Trials Related to Neighborhood Diversity Exposure



Note. The panel on the left depicts data from infants in the same language condition and the panel on the right depicts data from infants in the different languages condition. Plots show the relationship between the proportion of infants' looking to disagreement and proportions of households within participants' zip codes where a non-English language is spoken. See the online article for the color version of this figure.

LSBQ, rather than relying on language "categories." Indeed, replicating our main analyses using a dichotomous measure of language exposure (monolingual vs. bilingual) did not reveal an effect of language group, or an interaction between language group and condition (see https://osf.io/m539s/?view_only=9ac0ee7ce0e54d2f824bc701b85dd099 for data and analyses). Although this pattern means that we did not replicate the findings from Liberman et al. (2016), in which monolinguals and bilinguals showed different patterns of responses for actors who spoke different languages, it is likely that we were underpowered to detect such effects. That is, our sample included many infants who did not fit neatly into "monolingual" and "bilingual" categories (a strength of the LSBQ approach). Infants who are very strongly monolingual or bilingual may show a more divergent pattern of responses than infants with some language exposure (such that pure monolinguals are the most likely to expect same-language speakers to agree, and to be surprised when speakers of different languages agree), but only testing some infants does not allow researchers to investigate the full impact of individual differences in language exposure.

Discussion

We demonstrate that infants with more exposure to linguistic diversity at the interpersonal level were less likely to restrict their generalization of a food preference to members of the same-language-based social group. That is, infants with more exposure to linguistic diversity were more likely to expect that people who spoke different languages could like the same foods. By measuring exposure to linguistic diversity on a continuous scale rather than grouping participants as "monolingual" or "bilingual," this study revealed that individual differences in language exposure may matter for early language-based social categorization. Indeed, increased exposure to linguistic diversity at the interpersonal level was related to more flexible language-based social categorization.

Interestingly, we did not find similar effects for exposure to neighborhood linguistic diversity. On one hand, this was against our initial hypothesis, in which we did expect exposure to neighborhood linguistic diversity to predict more flexible categorization. Indeed, that pattern would have been consistent with past work demonstrating that infants from more linguistically diverse neighborhoods are more willing to imitate a member of a linguistic out-group (Howard et al., 2014). However, there are a few possible reasons why we would not see this pattern in our work. First, it is possible that infants' drive to socially interact with out-group members (e.g., by imitating them) is different from their cognitive ideas about category boundaries. That is, infants with more exposure to linguistic diversity in their neighborhood may be more willing to interact with out-group members while still recognizing that those people might be different from the in-group (e.g., might not share a food preference). Future work is needed in order to understand whether exposure to diversity has similar impacts for more cognitive measures of bias (e.g., stereotyping) as it does for more affective measures of bias (e.g., prejudice).

Additionally, it is possible that the diversity of an infant's neighborhood is a less valuable predictor of their social categorization overall. In fact, other recent work on infants' race-based categorization has similarly shown an effect of exposure to interpersonal diversity but not neighborhood diversity (Arnold et al., 2023). Specifically, in that work, infants with more racially diverse social networks show less of an own-race-bias in visual attention than infants with monoracial networks, but the racial diversity of an infant's neighborhood is not related to the size of the infant's other-race-bias. Thus, neighborhood diversity may generally be a less strong predictor of bias and categorization than social network

diversity in infancy. This could be the case if not all infants equally experience the diversity of their neighborhood. That is, some infants may go to daycare, religious institutions, and shopping areas in their neighborhood, others may not, meaning that neighborhood diversity does not always lead to meaningful cross-group contact. For example, research shows that people often do not experience the full diversity of their surroundings: Students report fewer cross-race friendships than would be predicted given the racial demographics of their schools (Wejnert, 2010), and cross-race and cross-class interactions occur less than would be predicted by chance within colleges (Carey et al., 2022). And, even in cases where there is diversity within a neighborhood, such exposure can have both positive and negative effects, depending on factors such as perceived threat and valence of intergroup interactions (see Craig & Richeson, 2018, for review). Therefore, more work is needed in order to determine when, if ever, the diversity present in an infant's neighborhood influences their patterns of social categorization.

Constraints on Generality

Our finding that interpersonal exposure to linguistic diversity may promote flexibility in infants' expectations about language-based categories opens many important questions for future research. First, are similar patterns seen for generalizing other types of information? We chose to focus on food preferences due to their cultural nature, so future research could ask whether infants exposure to diversity impacts the generalization of cultural properties (e.g., clothing choice, ritualistic behavior), but not noncultural ones (e.g., object preferences). Second, are similar patterns seen for other social categories? For example, are infants with more interpersonal exposure to racial diversity less likely to create strictly bounded racial categories? Third, do the effects of exposure to diversity persist across development? That is, do preschoolers, older children, or even adults make different inductive inferences about the importance of language based on their own exposure to linguistic diversity? And, do the effects of exposure to linguistic diversity extend to social and learning preferences (see, e.g., Begus et al., 2016)? Future research is needed in order to test whether infants with more exposure to linguistic diversity are more willing to approach, befriend, and learn from linguistic out-group members. Finally, our work was conducted in a lab setting in the United States, so it is possible that other settings would lead to different results. Therefore, without further study, these patterns may not be generalizable to other populations (e.g., in other countries with different demographics).

Conclusion

Children's learning about social categories begins in infancy (Liberman et al., 2017b, 2021). They can develop inductive inferences by generalizing information from one individual to other members of a social group, and thus rapidly learn about the world around them. However, our work suggests that the way children conceptualize the boundaries of these social categories may be related to the degree of interpersonal contact they have with members of other groups. Specifically, the more interpersonal contact infants have with individuals who speak different languages, the more willing they are to generalize food preferences across category boundaries. Thus, diversity exposure may play an important role in children's learning about members of different social groups.

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