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Role of bilingual experience in children's context-sensitive selective trust strategies

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Abstract

Early bilingual language experience can enhance children's social-cognitive skills for effective communication. This study examined whether individual variability in bilingual language diversity, measured by language entropy, influenced 3- to 5-year-old children's engagement of contextual information in their selective trust strategies. One-hundred-and-forty Singaporean children (58 girls, $M_{age} = 53.64$ months, 97.1% Asian) were presented with an informant who provided either accurate or inaccurate information in a context with either adequate or limited information access. Bilingual children with greater language diversity, compared to those with less language diversity, were more likely to adapt their accuracy-based selective trust strategy to the informant's circumstances (i.e, information access). Results provide new insights into the role of diverse linguistic experiences in shaping children's social cognitive development.

1. Introduction

A number of studies have demonstrated that children growing up bilingual show a heightened sensitivity to communicative cues that are indicative of a speaker's intent (e.g., Gampe et al., 2019; Groba et al., 2018; Levi, 2018), including nonverbal referential cues such as pointing and eye gaze (Yow & Markman, 2011a; Yow et al., 2017), paralinguistic cues such as tone of voice (Yow & Markman, 2011b), and pragmatic cues such as violations of conversational maxims (Siegal et al., 2010). There is also evidence that bilingual 3-year-olds showed an enhanced ability to integrate multiple cues, such as semantics, eye gaze, and context cues, to understand the interlocutor's referential intent compared to their monolingual peers (Yow & Markman, 2015). Furthermore, exposure to more than one language appears to advance the development of social-cognitive skills such as theory of mind (see Yu et al., 2021, for a review) and perspective taking (e.g., Fan et al., 2015; Liberman et al., 2017). Taken together, these findings suggest that growing up in a bilingual environment may result in a heightened sensitivity and a greater capacity in children to understand a speaker's communicative intent and integrate multiple aspects of the context.

One area that has not yet been explored is the role of bilingual experiences in children's ability to consider contextual factors when evaluating a speaker's reliability in communicative cues. The ability of children to track and adapt their selective trust strategies (such as trusting a reliable speaker over an unreliable speaker) according to the speaker's communicative context is an important social cognitive skill that guides children's selective learning in the social world (Harris et al., 2018; Koenig et al., 2019; Sobel & Kushnir, 2013; Yow & Li, 2021). In a classic selective trust paradigm (Koenig & Harris, 2005), children are introduced to speakers who either consistently provide wrong information or consistently provide correct information, and then are asked to make a preference choice or an endorsement decision. For example, in Palmquist and Jaswal's (2015) study, 4-year-olds were familiarized with two actors, a reliable actor who consistently provided accurate points (e.g., towards the correct location of a hidden object) and an unreliable actor who consistently provided inaccurate points. During test trials, children preferred the reliable actor over the unreliable one as a source of information about newly hidden objects. However, the use of accuracy cue in selective trust can be complex because an observable behavior may represent a speaker's true state of reliability in some but not all contexts. A speaker may provide accurate information due to competence, luck, or only with the assistance of others. Likewise, a speaker may provide inaccurate information due to incompetence, ignorance, or lack of access to the information. Using a speaker's history of accuracy alone could misguide children in their selective learning process – an appropriate strategy would thus require children to interpret the speaker's actions within the given context.

Our previous work suggests that children aged 3 to 5 years adopt context-sensitive strategies when conferring selective trust in an informant's referential cues such as pointing and

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eye gaze (Yow & Li, 2021). In that study, children interacted with an informant who provided either accurate or inaccurate referential cues to the location of a hidden object in a context with either information access or a lack thereof. When the informant had access to information and expressed certainty about her referential cues, children demonstrated selective trust, using the referential cues from an accurate informant more than an inaccurate informant. In contrast, when the informant lacked access to information and expressed uncertainty, children trusted information from both the accurate and the inaccurate informants to a similar degree. Most importantly, preschoolers who demonstrated an understanding of an informant's limited knowledge access and used context to excuse the past inaccuracy of the informant were more successful in using the referential cues to identify the object location than those who did not. This finding underscores the importance of the children's ability to interpret an informant's epistemic constraints within the broader communicative context when appraising an informant's reliability in selective trust.

Would bilingual experiences influence children's ability to consider contextual factors when evaluating a speaker's reliability in communicative cues, and if yes, why? There is evidence that infants' social-cognitive understanding is significantly related to individual differences in social interactive experiences (Brink et al., 2015). Howard et al. (2014) proposed that the diversity of the communities that one lives in largely influences social learning (e.g., imitation) very early in life. They tested 19-month-old infants from English-speaking monolingual households and found that exposure to linguistic diversity in their neighborhood significantly influenced children's tendency to learn from non-English-speaking social others. Similarly, children growing up in diverse linguistic communities are thus likely to be more attuned to the challenges regularly present in these children's sociolinguistic environments, which could further shape their social understanding and interactions with others (see Atagi & Rochanavibhata, 2022, for a review). While a child exposed to only one language would rarely encounter alternative linguistic systems, a child immersed in multiple languages would need to resolve the ambiguity of multiple labels for the same referents, track who speaks what language, and decide how to respond in the appropriate language form and content to avoid communicative failures (Comeau et al., 2007; Genesee et al., 1996). In other words, bilingual children regularly face a certain level of diversity or uncertainty with respect to language use. The regular experience of such communicative challenges with an increased need to monitor the changing communicative context (e.g., switching between speakers of different languages or cultures) could help finetune bilingual children's skillful management of their daily interactions (also see Gampe et al., 2019; Yow & Markman, 2016). This in turn suggests that bilingual children who experience more diverse communication situations (e.g., greater language diversity) would be more likely to consider contextual factors when evaluating a speaker's reliability in an interactional context than those with more homogeneous linguistic experiences.

Several social learning theories espoused the importance of children's environment in social cognitive development and provided rationale to our hypothesis. For example, Bronfenbrenner's ecological systems theory views child development as an interweaved system of relationships that are affected by various levels of the environment, from the immediate microsystem of family, childcare and school to the larger macrosystem of societal and cultural norms (e.g., see Bronfenbrenner, 2005). Thus, to understand children's development of selective trust strategies, we should look beyond a child's individual inclinations and consider the child and his/her immediate environment as well as the interaction of the environment. Exposure to a diverse linguistic environment could raise a child's awareness that interlocutors have different reasons for speaking in a certain way (or a specific language) in the microsystem. For example, an interlocutor who speaks Japanese labeled a familiar object in Japanese but a child who does not speak Japanese could not understand. The child could either interpret that the interlocutor is unreliable (for providing a wrong label) or that the interlocutor has a reason for labelling the object "wrongly" (speaks a different language) in this specific instance. This also means that whether the interlocutor is a reliable source of information in a different context can be updated in future interactions between the child and the interlocutor. While an informant's history of accuracy is an important (and useful, in most circumstances) epistemic cue that children can rely on to regulate learning, there are situations where history of accuracy alone may not be sufficient a cue to evaluate if someone is going to be reliable or not reliable. At the larger macrosystem level, the socio-cultural environment shapes and is shaped by the linguistic conventions of the local community (Nölle et al., 2020). A bilingual child could have observed communities of people being sympathetic to and aware of the context and constraints of others who struggle to communicate due to different cultural and linguistic backgrounds, and subsequently adapt their own interactions to the needs of these interlocutors. Similarly, the Social Cognitive Theory (Bandura, 1986, 1991, 2001) posits that children learn within a social context that interacts with the person, environment, and behavior. It highlights the role of social influence and emphasizes external and internal social reinforcement. It is possible that the diversity of the children's linguistic community places demands on communicative flexibility in social interactions, and children's selective trust strategies are then reinforced by both external (e.g., parents, peers, teachers, other social adults) and internal (e.g., the desire to interact and communicate effectively) social demands through observation and an intentional desire to learn from social others and adapt their behavior to the relevant social contexts.

Several studies supported our hypothesis that bilingual experiences in more diverse communication situations affect how children consider contextual factors when evaluating a speaker's reliability. For example, Wermelinger et al. (2017) examined three groups of 2.5-year-olds on their abilities to repair communication failures: monolinguals exposed to Swiss German, German bilinguals with exposure to two highly similar languages (i.e., Swiss German and Standard German), and non-German bilinguals who were exposed to Swiss German and another non-German language. They found that the non-German bilingual children, who were assumed to experience communication challenges more frequently than the Swiss German monolinguals and Swiss-Standard German bilinguals, were more likely to repair the interlocutor's misunderstandings compared to the latter two groups of children. Similarly, in Yow and Markman's study (2016), English-speaking monolingual and bilingual 3- to 4-year-olds heard instructions from an experimenter who spoke in either English only or English mixed with a foreign language. Children then played a hiding game that relied on the experimenter's nonverbal cues. They found that exposure to communicative breakdowns from unfamiliar language switches increased children's sensitivity to nonverbal communicative cues and led to better performance in both monolingual and bilingual children. Furthermore, bilinguals who were exposed to more code-switching incidences at home outperformed those who were exposed to fewer code-switching incidences in the mixed-language condition. These studies suggested that prior linguistic experience with challenging communicative situations might drive the differences in children's ability to infer a speaker's intent, including among bilingual children who differ in their bilingual experiences. It is worth noting that recent research has largely converged in agreement that individuals are not categorically monolingual or bilingual; rather, bilingualism should lie on a continuum from monolingual (i.e., no exposure to a second language) to completely bilingual (i.e., "balanced" bilingual experience; see Kremin & Byers-Heinlein, 2021, p. 1564; DeLuca et al., 2019; Luk & Bialystok, 2013; Surrain & Luk, 2019). Thus, in the current study, we consider bilingualism as a continuous construct and seek to investigate whether the degree of bilingual language diversity would influence the engagement of context-sensitive strategies in selective trust among bilingual children.

We used the same paradigm as Yow and Li (2021) where children see an experimenter hide a sticker into one of two boxes and then have to decide whether to rely on the experimenter's referential cues (e.g., pointing and eye gaze) to locate the hidden sticker. The experimenter's reliability in providing referential cues was established based on 1) the history of accuracy in providing referential cues (accurate vs. inaccurate experimenter), and 2) the specific communicative context (informed vs. uninformed experimenter, i.e., whether the experimenter has visual access to the information or not). Following Yow and Li (2021), we tested preschool-age children (3- to 5-year-olds) who are bilingual and live in Singapore, a multilingual, multicultural society. We conducted confirmatory analyses to test the modulating effects of language diversity on children's engagement in different selective trust strategies in the task. According to Yow and Li (2021), children's context-sensitive selective trust was assessed by a significant interaction effect of informant accuracy and context. Specifically, if children adjust their accuracy-based selective trust strategies in accordance with the informant's specific circumstances, we expect a significant effect of informant accuracy in the informed condition but not in the uninformed condition. Most importantly, we investigated the role of individual variability in bilingual language diversity, measured by language entropy (Gullifer et al., 2018; see Methods, for details), in children's selective trust strategies. If the extent of such bilingual language experience modulates children's use of selective trust strategies, we predict a significant three-way interaction between language diversity, informant accuracy, and context. In other words, children who experienced greater language diversity (i.e., regular exposure to diverse communication context) would be likely to selectively use the referential cues based on the informant's history of accuracy only in the informed condition but not in the uninformed condition. In contrast, we expected that children with lower language diversity would be likely to use the accuracy cue regardless of whether the informant has access to information or not.

We also included the assessments of children's English receptive vocabulary, inhibitory control, and working memory to control for the possible contribution of English proficiency in the task language (all children completed our study in English) and cognitive ability in explaining children's performance in our study. Previous research suggests that children with larger vocabularies are more willing to defer to what an informant says than children with smaller vocabularies (e.g., Jaswal, 2007). Inhibitory control and working memory may be involved in our task as children need to inhibit their tendency to follow the informant's referential cues (e.g., Jaswal & Kondrad, 2016) and track what the informant said and did throughout the study. Furthermore, bilingual experience has been argued to be associated with better inhibitory control and working memory – a greater capacity to detect and resist distractions from irrelevant cues and interferences, as well as to maintain attention in tasks that require high levels of monitoring (Greenberg et al., 2013; Kovács, 2009), which could in turn lead to stronger awareness of contextual information and better ability to (inhibit own's perspective and) take the perspective of others (e.g., Bialystok & Senman, 2004; Nguyen & Astington, 2014). Although the argument that bilingualism confers an advantage in development of executive functions such as inhibition and working memory has been challenged by recent large-scale and meta-analytic studies (e.g., Dick et al., 2019; Gunnerud et al., 2020; Lowe et al., 2021), it is nevertheless important to control for such variables in our study (also see Buac et al., 2019; Fan et al., 2015; Yow & Li, 2021; Yow & Markman, 2015; Yu et al., 2021).

2. Methods

2.1. Participants

Participants were 140 children (58 girls, 82 boys) between 3 and 5 years of age (mean = 53.64 months, range = 42 to 65). Children were randomly assigned to one of the four conditions: informed accurate, informed inaccurate, uninformed accurate, or uninformed inaccurate condition. We collected data until there were at least 32 participants in each condition, regardless of participants' language background, as this is the minimum sample size required for a power of .80 to detect a medium effect size (f = 0.25) for the main effects and interactions in a 2 x 2 between-subject design using G*Power 3.1 (Faul et al., 2009). Neither age nor gender distribution varied significantly between the conditions: informed accurate: 33 children (18 girls, 15 boys), mean age = 53.85 months; informed inaccurate: 39 children (11 girls, 18 boys), mean age = 54.03 months; uninformed accurate: 36 children (15 girls, 21 boys), mean age = 53.14 months; uninformed inaccurate condition: 32 children (14 girls, 18 boys), mean age = 53.50 months. All children were recruited from the same preschools located in a typical urban middle-class neighborhood in Singapore, and their school instruction was in English and Mandarin. Singapore is a multilingual, multi-cultural society. Children in Singapore, besides being required to learn two languages simultaneously in the classrooms (English plus one of three official "mother tongue" language: Mandarin, Malay, or Tamil) are often raised in families that speak other languages, such as Hindi, Cantonese, etc. All children in the study were reported by their parents to be simultaneous bilinguals (exposed to and acquired two languages from birth to 3 years old; Patterson, 2002). Despite the prevalence of English language in Singapore, there is a substantial amount of variability in their English exposure among Singaporean preschoolers (e.g., see Yow et al., 2017). The majority of participants were reported to be Asians (n = 135), while four were non-Asians, and one did not respond to this question.

A language background questionnaire was sent to parents of each child to obtain information about the language(s) the child was exposed to and the percentage of waking time the child hears and/or speaks each language. On average, children were reported to spend 70.4% of their waking time in their dominant

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language (range = 50–99%; e.g., English = 114, Mandarin = 21, Tamil = 3, and Japanese = 2) and 27.5% in their second dominant language (range = 1–50%; e.g., Mandarin = 99, English = 25, Tamil = 5, Malay = 4, Hindi = 2, Cantonese = 1, Filipino = 1, Korean = 1, German = 1, and Malayalam = 1). Some parents ($n = 58$) reported that their children spent an average of 5.2% time in a third language (Hokkien = 13, Mandarin = 7, Cantonese = 7; Malay = 8, Indonesian = 6, Teochew = 3, Marathi = 2, Japanese = 2, Hindi = 2, Spanish = 2, French = 1, Burmese = 1, Taiwanese = 1, Tamil = 1, Vietnamese = 1, unidentified dialect = 1). To quantify the diversity of bilingual language experience, we computed Shannon entropy associated with a child's proportional exposure of the two dominant languages L1 and L2 (i.e., language entropy; see Gullifer et al., 2018). Here, we define L1 and L2 as the two languages that a child hears and/or speaks the most during their waking time. To derive language entropy, we first computed a proportion of L1 and L2 exposure for each child by dividing the time spent in each language by the sum of the time spent in the two dominant languages. Next, we calculated language entropy, or bilingual language diversity, using the "languageEntropy" package in R (Gullifer & Titone, 2018). The equation used for this calculation is: Language Entropy = $-P_{L1}\log_2(P_{L1}) - P_{L2}\log_2(P_{L2})$, where P_{L1} and P_{L2} represent the proportion of time spent in L1 and L2, respectively. Theoretically, the entropy distribution has a minimum value of 0 indicating 100% exposure to only one language and a maximum value of 1 indicating maximal language diversity (50% exposure to each of both languages). In our sample, we observed a mean language entropy value of 0.78, ranging from 0.08 (low diversity) to 1.00 (maximal diversity). Information on maternal and paternal education was also collected as a measure for socioeconomic status (see Table 1).

2.2. Materials

The materials used in this study were ten identical transparent acrylic boxes with removable black lids (8 x 8.3 x 6 cm), a black cardboard screen (50 x 75.5 cm), two cardboard stands (with slots to support the screen), and a box of stickers. Four of the boxes were used in the warm-up and history phases for the informed conditions and four were used in the warm-up and history phases for the uninformed conditions. The latter boxes used in the uninformed conditions had three of their transparent sides covered with yellow construction paper (excluding the lid and the bottom of the box) leaving only one side transparent uncovered (i.e., partially occluded boxes). The remaining two boxes had all the sides covered with yellow construction paper (i.e., opaque boxes) and were used only in the test phase for all conditions.

Language Background Questionnaire (LBQ)

This parental questionnaire (adapted from Yow & Li, 2018) was used to derive children's language experience. Parents were asked to identify the language(s) their child has been exposed to (both in the past and present) and their child's age when he or she was first exposed to the language. For language exposure, parents estimated the percentage of waking time the child hears and/or speaks each language for a typical week.

Peabody Picture Vocabulary Test 4th Edition (PPVT-4)

PPVT-4 is a standardized instrument that measures receptive English vocabulary (Dunn & Dunn, 2007). The test was administered and scored following standard procedures. Each child obtained an age-based standardized score according to the manual.

Day-night Stroop task

The day-night Stroop Task (adapted from Gerstadt et al., 1994) measures children's inhibitory control. Sixteen testing cards were used in this task. There were two kinds of cards: half of the testing cards were white with an image of a yellow sun, while the other half of the testing cards were black and had a white crescent moon on it. Children were instructed to respond "night" when presented with the "sun" card, and "day" when presented with the "moon" card. Each child was scored based on the number of trials responded correctly.

Forward digit span task

The digit span task (adapted from Wechsler, 1974) measures children's working memory capacity. In this task, each child first listened to a string of digits and was instructed to repeat

Table 1. Descriptive statistics of demographic, language, and control variables for participants in each condition.

	Informed Accurate	Informed Inaccurate	Uninformed Accurate	Uninformed Inaccurate
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Age (months)	53.85 (4.86)	54.03 (4.56)	53.14 (5.40)	53.50 (4.37)
Age of second language acquisition (years)	1.00 (1.11)	0.83 (1.08)	0.89 (1.08)	0.66 (0.87)
Proportion of most heard/spoken language	0.73 (0.14)	0.68 (0.14)	0.71 (0.14)	0.70 (0.15)
Proportion of 2nd most heard/spoken language	0.25 (0.14)	0.29 (0.13)	0.27 (0.14)	0.29 (0.15)
Language entropy (0-1)	0.74 (0.22)	0.82 (0.19)	0.77 (0.23)	0.79 (0.23)
Parents' education (1-5)[a]	3.69 (0.78)	3.65 (0.84)	3.92 (0.84)	3.63 (0.82)
PPVT standard score	99.79 (12.70)	100.67 (10.29)	101.89 (14.49)	97.72 (13.69)
Day night task score	13.39 (2.94)	13.90 (2.30)	13.31 (3.39)	13.58 (2.86)
Forward digit span task score	6.76 (1.48)	6.31 (1.26)	6.39 (1.34)	6.77 (1.65)

Note. $N = 140$. PPVT = Peabody Picture Vocabulary Test.
[a] Mean of father's and mother's education level on a 5-point scale: 1 = *primary school*, 2 = *secondary school*, 3 = *pre-university*, 4 = *bachelor's degree*, and 5 = *master's degree or doctorate*.

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the digits in the order he or she heard. The first span included three digits. One digit was added for each subsequent span. There were two trials for each span. The longest span was nine digits. The digit span score was the total number of trials repeated accurately.

2.3. Procedure

Children were tested individually in a quiet room at their preschool. Parents provided written consent for their children to participate in the study, and the study was approved by the ethical board of the university where the research was conducted. Children's oral assent was obtained prior to their participation. In this study, children were asked to locate the sticker hidden in one of the two boxes. After playing the hiding game, children completed the forward digit span followed by the day-night Stroop task in the same session (about 15-20 minutes). All children completed PPVT-4 in a separate session, approximately one week after the first session. The experiment consisted of three main phases: Warm-Up, History, and Test phases. The Warm-Up and History phases varied depending on the condition while the Test phase was consistent across all conditions. The phases were presented in this order: Warm-Up, History 1, Test 1, History 2, and Test 2. There were two trials in the Warm-Up phase and four trials in each of the History and Test phases. Thus, children took part in a total of two warm-up trials, eight history trials, and eight test trials throughout the experiment. See Figures 1 and 2 for schematic illustrations of the experimental setup and procedure.

Warm-up phase

A female experimenter first introduced the hiding game to the child: "Hi! Today, we are going to play a game together, alright? In this game, you will need to help me pick out a box that has a sticker in it, ok?" In each warm-up trial, the experimenter presented the children with two boxes (one containing a sticker and one without), one at a time. The experimenter presented the boxes at the child's eye level, and the empty box was always presented first. In the INFORMED conditions (i.e., Informed Accurate and Informed Inaccurate), two fully TRANSPARENT boxes were used. In the UNINFORMED conditions (i.e., Uninformed Accurate and Uninformed Inaccurate), two PARTIALLY OCCLUDED boxes were used instead. For these two partially occluded boxes, the experimenter first showed the box with the transparent side facing the child and then turned the box clockwise slowly to show every covered side of the box until the transparent side appeared in front of the child again. Each box was then placed on the table, and the experimenter asked the child to select the box that contained the sticker, saying, "One of the boxes has a sticker in it. Can you pick the box that has the sticker in it?" while keeping her eyes fixed on the child. A response was considered made once the child pointed to or touched either of the boxes. There were two such warm-up trials, counterbalanced by the position of the baited box (left or right). This warm-up phase ensured that children understood the game. Children did not receive the stickers they found during the warm-up phase, and this is the same for the history phase (see below). All children successfully picked the box with the sticker in the warm-up trials.

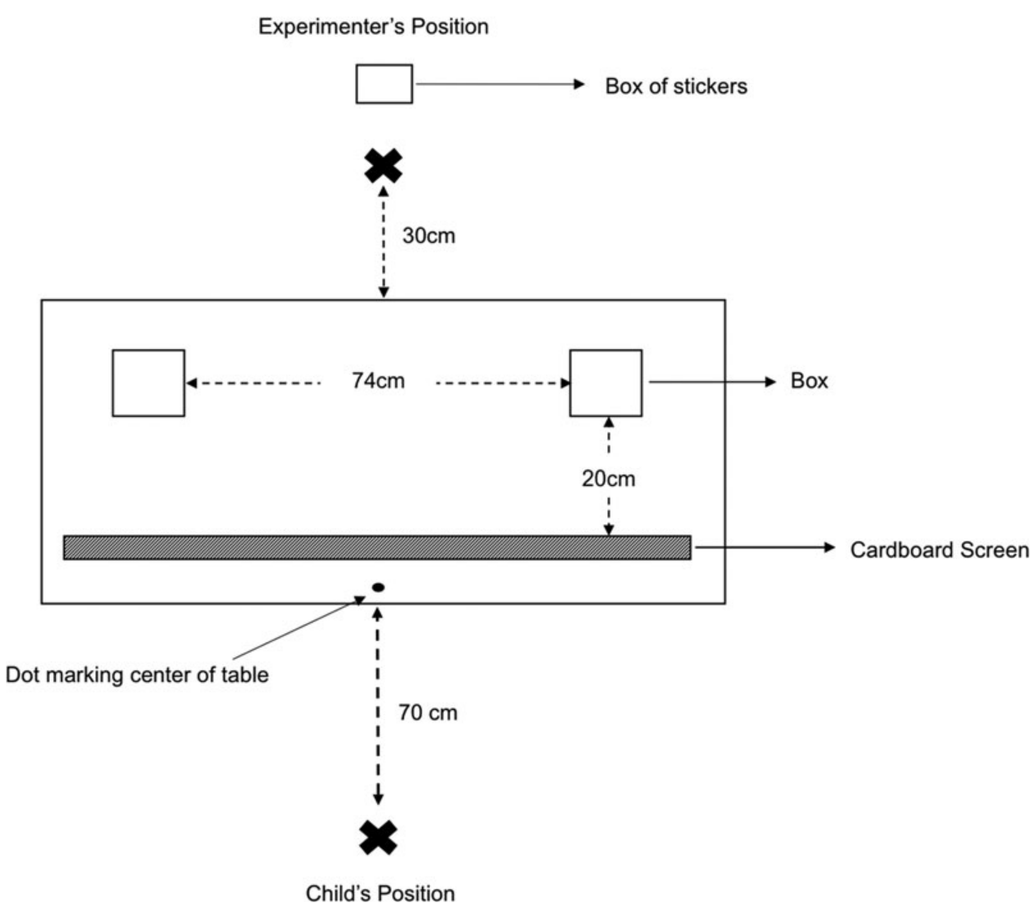

Figure 1. Schematic illustration of experimental setup.

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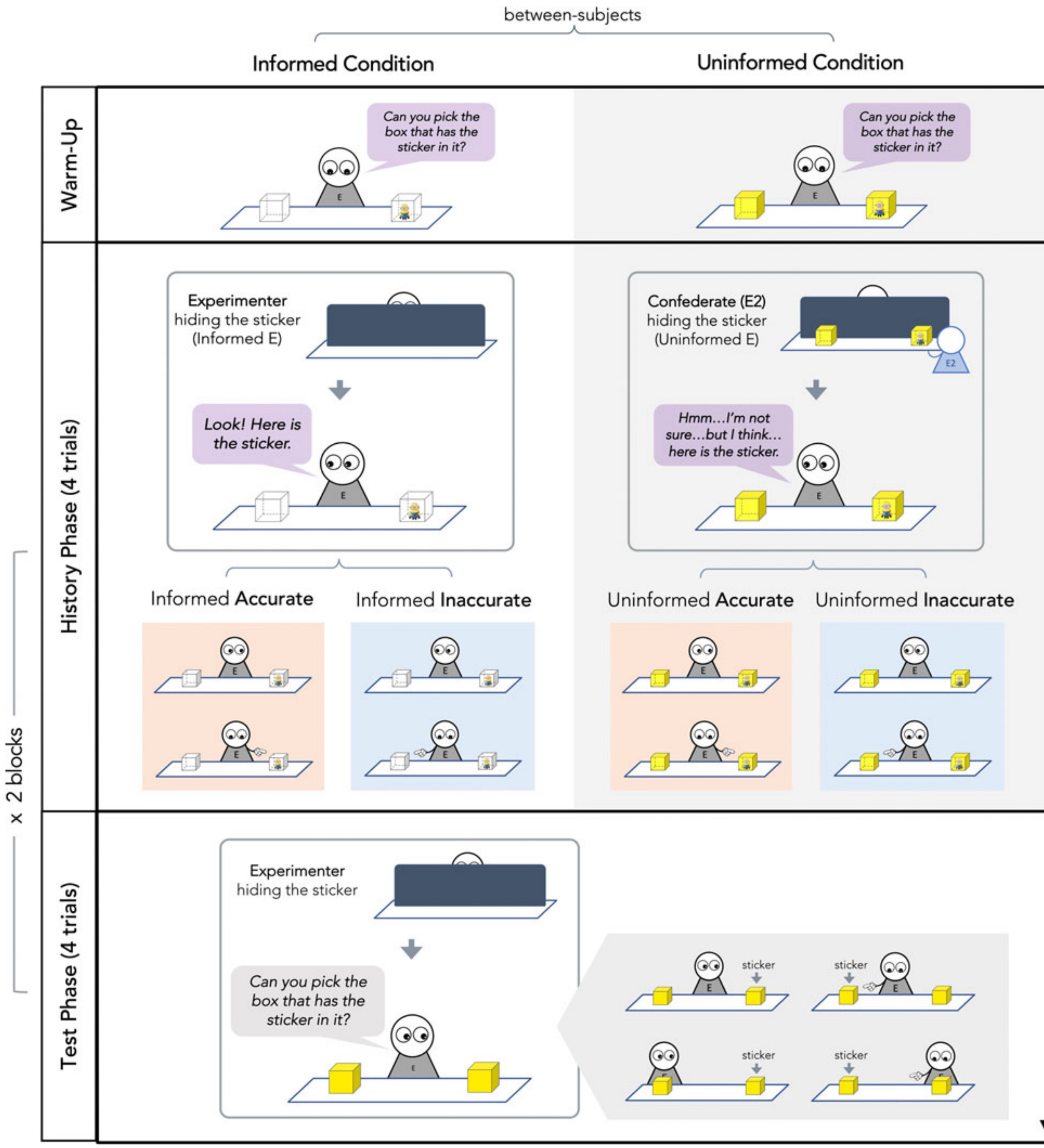

Figure 2. Experiment design and procedure. Children were randomly assigned to one of the four between-subjects conditions: Informed Accurate, Informed Inaccurate, Uninformed Accurate, or Uninformed Inaccurate. During the history phase, depending on the condition, the experimenter (E) either had visual access to the sticker location (informed condition) or not (uninformed condition), and then looked/pointed at either the box containing the sticker (accurate condition) or the empty box (inaccurate condition). During the test phase, all children saw E hide a sticker into one of two opaque boxes and were asked to choose the box they thought had the sticker. Throughout the test trials, E always provided accurate cues to the correct box while using different gestures (gaze or point) and at different positions (center or side), but the actual location of the hidden sticker was never revealed to the children.

History phase

The main purpose of the history phase was to establish the reliability history of the experimenter, depending on condition. The critical manipulation between conditions was (1) whether the experimenter provided accurate or inaccurate referential cues (i.e., accurate vs. inaccurate), and (2) whether or not the experimenter had access to the information that is key to providing accurate referential cues (i.e., informed vs. uninformed). Two empty boxes of the same type as in the warm-up phase were used; that is, transparent boxes for the informed conditions and partially occluded boxes for the uninformed conditions. The history phase also served as a check on whether children were able to locate the sticker regardless of the cues provided by the experimenter as described below.

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Informed accurate condition. In this condition, the experimenter always provided accurate cues toward the location of the sticker (i.e., the baited box). The experimenter first introduced two TRANSPARENT boxes to the child by bringing them to her eye-level one at a time, looked through them to emphasize the transparent properties of the boxes and explained, "Look at these two empty boxes. I am going to put a sticker in one of these two boxes." Next, a black cardboard screen was placed in front of the boxes, blocking the child's view. The sticker was then carefully placed in one of the transparent boxes, minimizing any sound that could indicate the location of the sticker to the child. The experimenter ensured that the child was still engaged in the task before removing the screen. After the screen was removed, the experimenter either pointed to or looked at the baited box and asked the child to pick the box with the sticker in it, saying, "Look! Here's the sticker! Can you pick the box that has the sticker in it?" (see Figure 2). The experimenter held her gestures until the child made a choice.

Informed inaccurate condition. The procedure was identical to the Informed Accurate condition, except that the experimenter always provided referential cues toward the incorrect location of the sticker (i.e., the empty box). Thus, the experimenter displayed a history of inaccuracy, despite her full (visual) access to the information about the sticker's location.

Uninformed accurate condition. The procedure was similar to the Informed Accurate condition where the experimenter always provided accurate cues toward the sticker's location, except that a confederate was involved in hiding the stickers and two PARTIALLY OCCLUDED boxes were used instead. The partially occluded boxes were introduced to the child in the same manner as the Warm-up phase. After the experimenter turned around, a black cardboard screen was placed between the experimenter and the boxes, blocking the experimenter's view. The confederate then put a sticker in one of the boxes. Note that in all uninformed conditions, the transparent side of the box would end up facing the child – hence only the child, but not the experimenter, could see the contents of the box during the history trials. After the screen was removed, the experimenter either pointed to or looked at the target box and asked the child to pick the box with the sticker, saying, "Hmm… I am not sure… but I think here is the sticker. Can you pick the box that has the sticker in it?" (see Yow & Li, 2021, for a discussion on the rationale for having the experimenter expressing ignorance that is consistent with the specific context).

Uninformed inaccurate condition. The procedure was identical to the Uninformed Accurate condition, except that the experimenter provided incorrect cues to the sticker's location (i.e., point or gaze at the empty box).

Throughout the History phase, the experimenter remained in the same centered position, equidistant from the two transparent boxes (see Figure 2). There were four trials in each history phase, including two trials with point cues followed by two trials with gaze cues, counterbalanced for side (left vs. right) of the baited box. For point cues, the experimenter pointed at one box using her index finger, with her arms partially extended and her eyes fixated on a dot marked on the center end of the table. For gaze cues, the experimenter turned her head and looked at one box, with her arms rested on her lap. All children correctly located the stickers in all eight history trials across the four experimental conditions.

Test phase

Two OPAQUE boxes were used in the test trials. At the beginning of each test phase, the experimenter introduced the two opaque boxes as per the warm-up trials. The interior of the boxes was also shown to inform the child that the boxes were empty. In each test trial, the experimenter told the child that she was going to put a sticker in one of the two opaque boxes and then put up the carboard screen to block the child's visual access to the hiding process. The experimenter then put the sticker in one of the boxes as quietly as possible. Next, the experimenter removed the screen, and while looking or pointing to the baited box, either seated equidistant between the two boxes or seated behind the empty box while gesturing toward the baited box, asked the child to locate the sticker: "Can you pick the box that has the sticker in it?" The experimenter maintained her gestures until the child responded by pointing to either of the boxes. This procedure was repeated for all three other test trials in the same test phase. Importantly, although the experimenter always provided accurate cues to the correct box, the actual location of the hidden sticker was never revealed to the children throughout the test trials. As such, children did not receive any feedback about the accuracy of their selections, and it is unlikely that children's subsequent choice in the test trials was the result of some strategy they had formed based on their performance in the previous test trials. All the eight test trials across two test phases were counterbalanced for gesture (point or gaze), position (equidistant or to one side) and side of the sticker location (left vs. right) across the conditions and participants.

3. Results

Preliminary analyses revealed no effect of gender, test order, position, and type of gesture on test performance, so these factors were not considered in subsequent analyses. The primary interest of this study was whether the degree of bilingual language diversity would affect children's ability to use information access to account for a speaker's past (in)accuracy. In the informed conditions (both accurate and inaccurate), the experimenter had visual access to the location of the hidden sticker, thus it would be reasonable for children to selectively trust the previously accurate experimenter but not the previously inaccurate experimenter. However, in the uninformed conditions (both accurate and inaccurate), the experimenter did not have access to the location of the hidden sticker. If children considered the experimenter's information access to explain the experimenter's prior inaccuracy, they would show comparable trust toward the previously accurate and inaccurate experimenter.

To test our hypothesis, we analyzed children's responses in the test trials as a function of the experimenter's past accuracy and information access. We conducted a mixed-effects logistic regression analysis using generalized linear mixed models (GLMMs) to predict the probability that the children would choose the box that was pointed to or looked at by the experimenter during the test trials. We fitted a GLMM model with Accuracy (dummy coded; accurate = 0, inaccurate = 1), Information Access (dummy coded; informed = 0, uninformed = 1), and Language Entropy (continuous, as described in Participants section) as predictors. The model also included the two- and three-way

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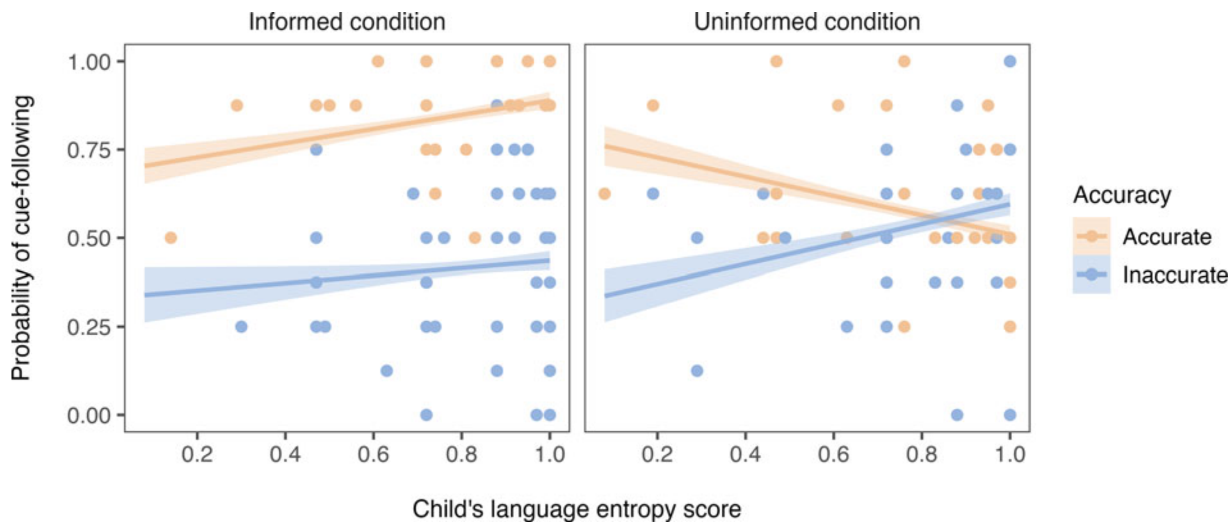

Figure 3. Children's tendency to follow the experimenter's cues in each condition based on the degree of bilingual language diversity, as measured through language entropy. Each dot represents an individual participant. Each curve represents the fitted values obtained from the generalized linear mixed model predicting probability of cue-following in the specific condition, and the shaded regions indicate 95% confidence intervals.

interaction effects of the predictors. Children's age was included in the model as a control variable.[1]

Results revealed significant main effects for Accuracy ($B = -2.32$, $SE = 0.30$, $z = -7.74$, $p < .001$) and Information Access ($B = -1.62$, $SE = 0.29$, $z = -5.57$, $p < .001$), but not for Language Entropy ($B = 1.58$, $SE = 0.97$, $z = 1.63$, $p = .10$). The main effect of age was not significant ($B = 0.09$, $SE = 0.23$, $z = 0.39$, $p = .70$). Overall, children were more likely to choose the box referred to by the experimenter if they were in the accurate condition (vs. inaccurate) or in the informed condition (vs. uninformed). There were significant two-way interactions of Language Entropy x Information Access ($B = -2.96$, $SE = 1.25$, $z = -2.36$, $p = .018$) and Accuracy x Information Access ($B = 2.18$, $SE = 0.39$, $z = 5.65$, $p < .001$), but not for Language Entropy x Accuracy ($B = -1.12$, $SE = 1.31$, $z = 0.86$, $p = .39$). In particular, the significant interaction between accuracy and information access replicated the findings of Yow and Li (2021). Most importantly, there was a significant three-way interaction of Language Entropy x Accuracy x Information Access ($B = 3.79$, $SE = 1.73$, $z = 2.19$, $p = .023$), suggesting that the two-way interaction effect between accuracy and information access was modulated by participants' language diversity.

To further explore this three-way interaction, for each information access condition, we ran a GLMM with Accuracy, Language Entropy, Accuracy x Language Entropy, and age as predictors (see Figure 3). In the informed condition, results revealed that only Accuracy was significant ($B = -2.32$, $SE = 0.30$, $z = 7.63$, $p < .001$) and no other significant effects were found. When the experimenter had full information access during the history phase, children generally engaged in accuracy-based selective trust strategies such that they were more likely to choose the box referred to by the accurate experimenter than the inaccurate experimenter. In the uninformed condition, in contrast, we found a marginally significant main effect of Language Entropy ($B = -1.25$, $SE = 0.72$, $z = -1.75$, $p = .080$), and more importantly, a significant interaction between Accuracy and Language Entropy ($B = 2.51$, $SE = 1.04$, $z = 2.41$, $p = .016$). When the experimenter's visual access was blocked during the history phase (i.e., uninformed condition), the degree of language diversity modulated children's selective trust based on the experimenter's history of accuracy. Specifically, the higher the degree of bilingual language diversity, the more likely children would trust the referential cues of both the accurate and inaccurate experimenters to locate the hidden object to a comparable extent in the uninformed condition (see Figure 3). These results suggested a significant effect of bilingual experience – specifically, language diversity – on preschoolers' consideration of contextual factors such as an experimenter's information access when evaluating the reliability of the experimenter's referential cues.

Lastly, we constructed three GLMM models to test whether children's English vocabulary (PPVT score), inhibitory control (Day-Night score) and working memory (Digit-Span score) skills predicted their performance in the test: each model was fitted with the PPVT/Day-Night/Digit-Span score as a continuous variable, Accuracy, and Information Access as predictors, all two-way and three-way interaction terms, as well as children's age as a control variable. We did not find any significant main effects or interaction effects of PPVT, Day-Night, or Digit-Span performance in these models (see Supplementary Materials, for a summary of regression coefficients), suggesting that individual variability in English vocabulary size, inhibitory control, and working memory did not modulate children's test performance across different experimental conditions. Furthermore, including children's PPVT, Day-Night, or Digit-Span scores as a control variable in the main analyses of bilingualism effects did not qualitatively change the results reported above (i.e., the significance levels stayed the same, see Supplementary Materials).

4. Discussion

In this study, we explored whether regular exposure to diverse linguistic environments modulates preschoolers' strategies in using

[1]We also ran the GLMM analysis with an additional control variable of children's proportional exposure to a third language (L3), to account for the variability in L3 exposure (a value of "0" was assigned for children who were exposed to only two languages). Including this control variable in the analysis does not change our results (see Table S1 of the Supplementary Materials for details).

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contextual information to determine whether to accept or disregard communicative information from a speaker. While past studies typically examined how well bilingual children use communicative information to learn about the world (e.g., the referent of a word or the location of a hidden toy) from reliable others, here we examined the effects of bilingual language experience on children's ability to consider the context of the accuracy-based information in conjunction with selective trust strategies to make sense of the behavior of others. We found that 3- to 5-year-olds who were exposed to a higher degree of language diversity, compared to their peers otherwise, were more attuned to the context (e.g., information access) under which the speaker's inaccuracy occurred and adopted different strategies when evaluating and predicting whether the speaker could be a reliable source of information in future situations – they were less likely to rely on accuracy-based strategies to evaluate a speaker whose reliability could have been affected by the circumstance (lack of visual access). The current findings provide novel support for a positive effect of bilingual language diversity on children's engagement of contextual information in selective trust.

This relatively sophisticated strategy of giving lesser weight to a speaker's prior inaccuracy due to an inadequate perceptual access in selective trust can be regarded as an adaptive approach, such as to reduce the risk of missing out on future useful advice from a potentially reliable informant. Our study is in line with the communicative challenge account that greater diversity in one's language experience could have facilitated the adoption of such a strategy, which likely stems from the exposure to diverse linguistic environments that demands greater communicative flexibility in interpersonal interactions (e.g., Gampe et al., 2019; Graf Estes & Hay, 2015; Kovács & Mehler, 2009; Yow & Markman, 2016). The extent of language entropy, as measured in our study, serves as an indicator of the extent of diversity in children's immediate linguistic environments, which could vary greatly between bilingual families. For instance, Orena et al. (2019) examined 10-month-old French–English bilingual infants on their proportion exposure to each language in daily interactions. Results showed that there was a considerable amount of variability in how much caregivers used each language across families, as well as within-individual variability in language exposure between weekdays and weekend days (likely a result of changes in children's activities). The between- and within-individual heterogeneity of language experiences can underscore the complexity of the communicative contexts that such individuals must learn to navigate in.

Humans are selective in what, when, and from whom they learn because of biological and time constraints; as such, we have evolved with adaptive capabilities to learn and use selective information provided by others to guide our own learning and understanding of the world. It is interesting to note that even animals will selectively follow or ignore social information under specific circumstances, such as reliability and relevance (Pelgrim et al., 2021; Van Bergen et al., 2004). As per the social learning theories described earlier, such as the ecological systems theory and the social cognitive theory, exposure to a diverse linguistic environment would raise a child's awareness and understanding of the sociolinguistic conventions that interlocutors have different reasons for speaking in a certain way (or a specific language), and that in turn would catalyze the development of adaptive skills in social learning. Our results suggest that the ability among children with high language diversity to consider the context (e.g., information access) under which the speaker's inaccuracy occurred and then adopt different selective trust strategies can be interpreted as an example of how dynamic social environments may reinforce social learning and shape early social cognitive development.

Nevertheless, an alternative explanation for our results could be that children with more intensive bilingual experience may show better performance in our study due to their increased executive functioning (EF) capacity to engage with task-relevant information (e.g., experimenter's perceptual access) and disengage from information that is less relevant or useful to complete a task at hand (e.g., experimenter's past accuracy in a specific situation) (Barac et al., 2016; Crivello et al., 2016; see Bialystok, 2017, for a review). However, we found no support for this EF account. Our data revealed that individual differences in Day-Night and Digit-Span tasks (two common EF measures of children's inhibitory control and working memory, respectively) did not account for the observed differences in the strategy that children used to evaluate the speaker in our task (see also Fan et al., 2015, for no links between enhanced EF measured by the Dimensional Change Card Sort task and children's better communication skills). One important caveat, though, is that the two EF tasks that we used here may not have captured the key executive processes (such as attention shifting) that could have helped children succeed in using context-sensitive strategies in our study. EF is a complex, multi-component construct, and it embraces a variety of cognitive processes that also include task shifting (e.g., Friedman et al., 2016), executive attention (e.g., Bialystok, 2017; Posner & Rothbart, 2007), etc. Furthermore, most EF tasks suffer from a task impurity issue there are no "pure" measures of distinct EF components, and the various EF tasks likely tap into multiple executive functions (Miyake et al., 2000). However, recent research using electroencephalogram (EEG) methods (Phelps et al., 2022) points out that bilingualism experience may modulate children's executive control processing through a redistribution of the available cognitive resources, rather than its increased capacity, suggesting different neurocognitive mechanisms of EF associated with bilingualism. Therefore, future work could consider a more holistic examination of individual differences in multiple EFs or applying neurological methods to understand the specific role of executive functioning in explaining the effects of bilingualism found in the current study.

It is possible that bilingual children's ability to take into consideration a speaker's context circumstance is directly related to their theory of mind skills (e.g., Kovács, 2009; Rubio-Fernández & Glucksberg, 2012; see Schroeder, 2018, for a meta-analysis of studies with children; but see Bialystok & Senman, 2004; Diaz & Farrar, 2018, for mixed results). Bilingual children were reported to perform better than monolingual children in tasks measuring false belief understanding (e.g., Goetz, 2003; Nguyen & Astington, 2014) and perspective-taking (e.g., Fan et al., 2015; Greenberg et al., 2013), and this advantage appears to emerge as early as infancy (Liberman et al., 2017). One might question whether such potential differences in theory of mind abilities between monolingual and bilingual children could have contributed to the observed differences in our study. While the ability to understand false beliefs or take the perspective of others would be helpful in understanding others' communicative intention, it is unlikely that this is the main reason driving our results. As an exploration, we asked children who participated in the uninformed conditions, at the end of the study, whether they believe that the experimenter could or could not have seen the hidden sticker during the history phase: we showed children a picture of the experimenter sitting behind the table with two partially occluded boxes placed in front of her where her view into the box was blocked (see Figure S1 in Supplementary Materials). We found that the variability in language diversity did not predict whether the child would interpret the experimenter's perspective correctly and answer that the experimenter could not see the hidden sticker. Furthermore, we found no significant main effects or interaction effects of such perspective-taking in predicting children's test performance ($ps > .16$). This suggests that bilingual children with greater language diversity were more likely to adapt their selective trust strategies based on the context than their peers with lesser language diversity (our study results) DESPITE these children being equally adept in interpreting the experimenter's perspective. We noted that there are limitations to such post-study inferences, and it remains plausible that other social-cognitive processes, such as how well children utilize their understanding of false-belief and others' perspective for social purposes, play an important role in children's consideration of the communicative context in selective trust.

Our task required children to evaluate whether the experimenter would provide reliable information about an object's location through the pointing or eye gaze. Such episodic information is typically regarded as transient, and someone's episodic knowledge is more likely to change as a result of the evolving context as compared to semantic or conceptual knowledge (e.g., referring to a cat as "a cat") that is rather stable and less dependent of the situation (see Brosseau-Liard & Birch, 2011; Kalish, 2002). Several studies have compared children's responses to an informant's episodic versus semantic errors in selective trust (e.g., Palmquist & Fierro, 2018; Palmquist & Jaswal, 2015; Stephens & Koenig, 2015; see Koenig et al., 2019, for a review). These studies suggest that although preschoolers are equally good at identifying individuals who have provided episodic and semantic misinformation, they are more likely to associate a speaker's ignorance with semantic errors than episodic errors such that children would mistrust the point of a previously inaccurate labeler, but not for the label of a previously inaccurate pointer (Palmquist & Jaswal, 2015). Additionally, it was found that preschoolers would excuse a speaker's past inaccuracy due to his/her inadequate information access in studies where they were presented with speakers who made episodic mistakes (e.g., Nurmsoo & Robinson, 2009a; Robinson & Nurmsoo, 2009) but not when they were exposed to speakers who made semantic errors in other studies (e.g., Nurmsoo & Robinson, 2009b). Despite this "bias" against semantic errors but yet more "forgiving" toward episodic errors given contextual limitations, it is possible that regular bilingual exposure can heighten children's sensitivity to contextual information such that bilingual children would equally consider a speaker's circumstantial constraints regardless of the type of errors (semantic vs. episodic). Future studies could extend our investigation of the effect of bilingual language diversity on selective trust with semantic errors.

So far, we have interpreted children's choice in our task as a result of their ability to use contextual information to decide whether to accept or disregard communicative information from a speaker. However, one might question what motivated children to choose a box in the test trials since they did not receive any feedback. We noted that at the beginning of the task, the experimenter told children that she would need their help to locate the box that has the sticker in it. Importantly, all children in our study accurately located the correct box with the sticker in it in all warm-up and history trials. This suggests that children understood that in this game, they are to choose the box that has the sticker in it. Preschoolers often find such hide-and-seek type of games fun, even without any feedback or reward, likely due to the autonomy and choice involved in the game (Goodhall & Atkinson, 2019). Nevertheless, it would be interesting for future research to consider asking children to explain their choice to better understand children's motivation to perform certain tasks in such social learning contexts.

It is also important to note that pure monolingual communities are rare, especially in today's highly connected world. At least 60% of the world's population consists of people who speak two or more languages. Even in officially monolingual countries (those with a single language policy, such as Russia, China, France), the local linguistic communities include their own regional and local varieties of language. In fact, multilingual practices already existed in the ancient times. For example, in the ancient Greek epic, the Odyssey, dated back to the twelfth century BCE, the island of Crete was described as: "There is a land called Crete; ringed by the wine-dark sea with rolling whitecaps; handsome country, fertile, thronged with people well past counting; boasting ninety cities, language mixing with language side-by-side" (Homer, 1996, pp. 172–175). Nonetheless, the study of linguistic diversity is complex. There are communities that are dominant in one language and a limited exposure to a second or more languages, and there are communities with hundreds of language varieties where people find ease in switching in and out of many languages (and many others in between). Even within our study sample, although we described our participants as "bilingual" for the purpose of the study, some children (58 out of 140) were reported to have some exposure to a third language, albeit minimal (average of 5.2% of the time). Nevertheless, our study is a first step toward understanding how language diversity (i.e., bilingual language experience) can play a role in social learning and cognitive development in children. Future studies should critically examine this research by extending it to children from various diverse language backgrounds for example, children who predominantly speak one language but are regularly exposed to L2 speakers of low proficiency, children who speak two varieties of the same language (i.e., bidialectal), or children with regular exposure to more than two languages (i.e., trilingual or quadrilingual).

In sum, this work presents important findings that bilingualism, or more specifically, diverse dual language experience, provides opportunities for children to develop adaptive communicative skills (i.e., sensitivity to the context and/or the speaker's communicative intent) that can shape their selective trust strategies. Our findings supported the notion that social cognitive development is shaped by our broader neighborhood environments and communities, where the diversity of social contexts guides the process of learning and development (see Leventhal & Brooks-Gunn, 2000; Killen et al., 2011; McGlothlin & Killen, 2010). A linguistically diverse environment, therefore, is an example of such a context where children's social cognitive development could be enriched and enhanced.

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Competing interests. The authors declare none.

Data availability. The data that support the findings of this study are openly available in Open Science Framework at https://osf.io/2j9rn/?view_only=84193e81459b4b149c71156006278558.

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