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The development of fast-mapping and novel word retention strategies in monolingual and bilingual infants

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Abstract

The mutual exclusivity (ME) assumption is proposed to facilitate early word learning by guiding infants to map novel words to novel referents. This study assessed the emergence and use of ME to both disambiguate and retain the meanings of novel words across development in 18-month-old monolingual and bilingual children (Experiment 1; N = 58), and in a sub-group of these children again at 24 months of age (Experiment 2: N = 32). Both monolinguals and bilinguals employed ME to select the referent of a novel label to a similar extent at 18 and 24 months. At 18 months, there were also no differences in novel word retention between the two language-background groups. However, at 24 months, only monolinguals showed the ability to retain these label–object mappings. These findings indicate that the development of the ME assumption as a reliable word-learning strategy is shaped by children's individual language exposure and experience with language use.

1 | INTRODUCTION

The ability to disambiguate the meanings of unfamiliar words presented in ambiguous naming situations is well documented among young children (e.g., Diesendruck & Markson, 2001; Liittschwager & Markman, 1994; Markman, Wasow, & Hansen, 2003). This ability has been traditionally attributed to several word-learning constraints, principles, or assumptions available to children during the early stages of lexical acquisition (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1990). One of these assumptions is mutual exclusivity (ME), which refers to the assumption that there are one-to-one correspondences between words and their meanings (Markman, 1990; Markman & Wachtel, 1988). While ME may be a useful default assumption, it does not apply to all word-learning situations, especially those faced by bilingual infants who learn more than one label for most referents in their environment (Byers-Heinlein, 2013). In this study, we investigate the developmental trajectory of infants' ability to learn and retain word–referent mappings using ME. We also investigate the effects of individual linguistic experience on the use of ME, particularly for infants who grow up acquiring one versus two languages.

One of the most studied manifestations of ME is the *disambiguation effect* (Merriman & Bowman, 1989), which has been typically assessed using implicit measures such as the intermodal preferential looking tasks, or interactive paradigms, in which children are presented with a familiar (e.g., a ball) and a novel referent (e.g., a whisk) and are required to select one of these objects in response to an unfamiliar label (e.g., *show me **the whisk***). If children rely on ME, they are predicted to select the novel instead of the familiar object (the ball already has a label, so the other object must be *the whisk*). Extensive evidence has demonstrated that young infants (Bion, Borovsky, & Fernald, 2013; Halberda, 2003; Kalashnikova, Mattock, & Monaghan, 2016; Mather & Plunkett, 2011), preschool and school-aged children (Diesendruck & Markson, 2001; Halberda, 2006; Markman & Wachtel, 1988), and adults (Halberda, 2006; Kalashnikova, Mattock, & Monaghan, 2014; Malone, Kalashnikova, & Davis, 2015) show this behaviour in a variety of adaptations of the task.

The capacity to reason by exclusivity in tasks testing the disambiguation effect has been ascribed to general attentional biases that are not specific to the process of lexical acquisition (Dysart, Mather, & Riggs, 2016; Hollich et al., 2000; Horst, Samuelson, Kucker, & McMurray, 2011; Samuelson, Kucker, & Spencer, 2017; Samuelson & McMurray, 2017). For example, infants as young as 10 months select novel instead of familiar objects in response to novel labels based on biases to attentionally salient (Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006) and novel objects (Mather & Plunkett, 2010). As infants acquire more advanced linguistic knowledge, this default bias has been proposed to evolve into a more sophisticated lexical strategy (Graham, Poulin-Dubois, & Baker, 1998; Mervis, Golinkoff, & Bertrand, 1994). For example, Grassmann, Schulze, and Tomasello (2015) assessed the disambiguation effect in 2-, 3-, and 4-year-old children, manipulating the degree to which children were familiar with the labels of the familiar objects used as distracters in the task. Their findings showed that children who were more familiar with the distracters' labels were more likely to exhibit disambiguation, suggesting that children's lexical knowledge guided their tendency to assume that a novel label does not refer to a familiar object. More recently, Kalashnikova, Mattock et al. (2016) assessed ME use in 17- to 19-month-old infants. Their findings also showed that only infants with larger receptive vocabularies were able to fast-map novel labels to their referents by showing the disambiguation effect. Therefore, infants' lexical knowledge is likely to support the consolidation of ME into a reliable word-learning strategy (Graham et al., 1998).

Increasing linguistic experience also plays a role in the transition from children's reliance on ME solely for purposes of fast-mapping to their ability to retain the new word–referent mappings (Samuelson et al., 2017). That is, while very young children are able to select a novel referent in response to a novel label, this behaviour does not necessarily imply learning or retention of this mapping. In fact, several studies have shown that 24-month-old children are unsuccessful at recognizing the referents of novel labels that they had successfully fast-mapped by relying on ME, either immediately following the referent selection trials or after a brief delay (Bion et al., 2013; Horst & Samuelson, 2008). However, it appears that retention abilities begin to emerge around 24 months, as children this age can succeed in retention tasks when ostensive cues to naming (e.g., reinforcement of the mapping between the label and referent provided by the experimenter in the referent selection trials) and when pre-exposure to the target objects are added to the referent selection trials (Horst & Samuelson, 2008; Kucker & Samuelson, 2012; Spiegel & Halberda, 2011).

The past literature therefore suggests that the use of ME in early lexical acquisition emerges as a product of the interaction between general attentional processes and children's growing linguistic experience (McMurray, Horst, & Samuelson, 2012; Samuelson et al., 2017). In line with this view, the early experience of acquiring two languages has also been proposed to impact infants' tendency to rely on ME. While monolingual infants observe that one-to-one mappings between words and their referents are common in their linguistic input, this is not the case for bilingual infants, who acquire referentially overlapping labels from their two languages (Pearson, Fernández, & Oller, 1995). Byers-Heinlein and Werker (2009) assessed reliance on ME in 17-month-old monolingual, bilingual, and trilingual infants and found that infants' performance depended on their linguistic background. Specifically, monolingual infants successfully employed ME, as did bilingual infants but to a significantly lesser extent, with trilinguals performing at chance. Similarly, Houston-Price, Caloghiris, and Raviglione (2010) found significant differences in 18- to 22-month-old monolingual and bilingual infants' performance in a disambiguation task. In fact, in their study bilinguals showed no evidence of relying on ME. Hence, the weight of evidence suggests that multilingual children's experience with more than one language delays the emergence of ME as a word-learning strategy.

In fact, a more recent study by Byers-Heinlein and Werker (2013) demonstrated that the composition of their lexicon, rather than their language exposure per se, prevents bilingual infants from developing an ME assumption. In their study, 17- and 18-month-old bilinguals did not demonstrate a disambiguation effect at the group level. However, an analysis of individual differences showed that bilinguals who knew fewer translational equivalents did show the effect, while those who knew many translational equivalents did not. Nonetheless, it is not the case that increasing experience of learning two languages completely precludes bilingual children from employing ME in referent selection tasks. That is, bilinguals between 2 and 4 years of age use the ME assumption to the same extent as their monolingual peers (Byers-Heinlein, Chen, & Xu, 2014; Davidson, Jergovic, Imami, & Theodos, 1997; Davidson & Tell, 2005; Kalashnikova, Mattock, & Monaghan, 2015). Therefore, it continues to be debated how the emergence of the ME assumption interacts with children's bilingual experience and growing lexical competence within and across their languages. Furthermore, the ability to retain labels mapped via reliance on ME has not been previously investigated in bilingual infants and children. This allows for the possibility that bilingual children may manifest ME in referent selection or fast-mapping tasks, but may not employ it as a reliable word-learning

RESEARCH HIGHLIGHTS

- Reliance on mutual exclusivity for fast-mapping and word retention was assessed in 18- and 24-month-old monolingual and bilingual children.
- Monolinguals and bilinguals showed ME in a fast-mapping task at 18 and 24 months.
- Monolinguals and bilinguals showed retention of the labels at 18 months, but only monolinguals showed retention at 24 months.
- With increasing experience with language use, ME is transformed into a reliable word-learning strategy for monolingual but not for bilingual children.

strategy, which would lead to failure in retaining the established word–referent mappings.

To summarize, recent evidence challenges the view of ME as a lexical constraint available from the onset of language acquisition. Instead, a dynamic view of the ME assumption (McMurray et al., 2012; Samuelson et al., 2017; Samuelson & McMurray, 2017) proposes that the tendency to reason by exclusivity in fast-mapping situations emerges as a product of general learning or attentional biases, and only later with increasing lexical competence develops into a reliable strategy used for identifying and retaining novel word–referent mappings. The developmental trajectory of the ME assumption in bilingual children, however, remains unknown. That is, on the one hand, it is possible that bilingual experience delays the emergence of this assumption. This would account for the evidence that ME is manifested in bilinguals to the same extent as in monolinguals only after 2 years of age. On the other hand, it is possible that the extensive experience of learning cross-linguistic equivalents leads bilinguals to maintain ME as a default fast-mapping heuristic, but never adopt it as a reliable word-learning strategy.

In this study, we assessed monolingual and bilingual infants' ability to use ME to both select and retain referents for novel labels at 18 and 24 months. In Experiment 1, 18-month-old infants from the two language background groups completed a fast-mapping task that included disambiguation and retention trials. Experiment 2 followed a subset of the children who participated in Experiment 1 six months later, re-testing them on the same task. For Experiment 1, we predicted that monolingual 18-month-old infants would exhibit ME in disambiguation trials to a greater extent than bilinguals (Byers-Heinlein & Werker, 2009, 2013; Houston-Price et al., 2010). However, we expected that at this age infants in the two groups would not be successful at retaining the mappings (Bion et al., 2013). For the 24-month-olds in Experiment 2, we predicted that both monolingual and bilingual infants would rely on ME to a similar extent (Byers-Heinlein et al., 2014). In addition, given that the retention phase was presented in this task immediately after the disambiguation task (and therefore without a delay), we predicted that monolingual children would show the ability to retain the learned labels (Kucker & Samuelson, 2012; Spiegel & Halberda, 2011). However, it was predicted that bilinguals would exhibit a lower rate of retention than monolinguals because past research suggests that, in comparison to monolinguals, bilinguals do not (i) develop an early disambiguation effect (Byers-Heinlein & Werker, 2009; Houston-Price et al., 2010), and (ii) are more likely to suspend this assumption to accept referentially overlapping labels (Kalashnikova, Mattock et al., 2016; Kandhadai, Hall, & Werker, 2017). This would indicate that ME may not be consolidated as a word-learning strategy for children learning more than one language. In addition, it was predicted that bilingual children's reliance on ME would be related to their individual language-use experience (Byers-Heinlein & Werker, 2013). That is, bilingual children who receive less exposure to their additional language were expected to show greater disambiguation and retention scores in this paradigm at both 18 and 24 months of age.

2 | EXPERIMENT 1

2.1 | Method

2.1.1 | Participants

Fifty-eight 18-month-old infants participated. Thirty-three (17 female, M_{age} = 78.3 weeks, SD = 1.6) were monolingual infants acquiring English and did not have exposure to any other languages. Twenty-five infants (16 female, M_{age} = 78.4 weeks, SD = 1.4) were raised in a bilingual environment acquiring English and an additional language. The monolingual and bilingual groups did not differ in their SES according to the average weekly family income calculated based on the postcode of their residence (upper middle range for monolinguals and bilinguals, Kolmogorov-Smirnov, Z = 1.222, p = .101), and according to maternal educational levels (university degree for monolinguals and bilinguals, Kolmogorov-Smirnov, Z = .438, p = .991). An additional 20 monolingual and 21 bilingual infants were tested but were not included in the final sample due to premature birth (3), insufficient exposure to English or the additional language (9; see Language Background below), failure to calibrate or to capture sufficient gaze data for analyses (12), and failure to complete the task due to extreme fussiness (17).

2.1.2 | Language background

Bilingual infants' caregivers completed an adaptation of the Language Background Questionnaire (Sabourin, Leclerc, Lapierre, Burkholder, & Brien, 2016). In this questionnaire, caregivers are asked to report their own language background, proficiency, and patterns of language use (i.e., language used at home, with their child, with other family members), in addition to their child's patterns of language exposure. The present adaptation also requires caregivers to complete a table detailing the number of hours per week their child is exposed to the two languages. This information was used to obtain the percentage of the child's exposure to English and their additional language by calculating the percentage of weekly awake time that the child spent exposed to each language. Six primary and six secondary caregivers were native speakers of English, and only two caregivers were monolingual English speakers. The remaining caregivers were native speakers of an additional language and spoke English as a second language. All bilingual infants were exposed to their two languages either from the same parent (i.e., bilingual parent using English and another language to speak to the child) or from different parents (i.e., one parent–one language approach) at home. The additional languages were: Cantonese, Mandarin, Vietnamese, Tigrinya, Tamil, Arabic, Korean, Spanish, Russian, Greek, Hindi, and Afrikaans. Prior to visiting the lab, infants' parents were contacted by a research assistant who asked them to provide an estimate of their infant's exposure to each language, and they were invited to take part if infants received at least 20% exposure to one of their languages. However, after completing the Language Background Questionnaire, it was identified that nine infants did not satisfy this selection criterion, so they were excluded from the present study. Parents of the remaining infants reported that their infants were exposed to English from 24% to 78% of time during an average week (M = 49.2%, SD = 15.8%) and from 22% to 76% of time to their other language (M = 49.1%, SD = 15.9%). Six infants also were reported to receive less than 10 hours of exposure to a third language per week (M = 7.1 hours).

Monolingual and bilingual infants' English vocabulary size was assessed using the OZI: Australian English Communicative Development Inventory (CDI) (Kalashnikova, Schwarz, & Burnham, 2016). The OZI is an Australian English adaptation of the MacArthur-Bates CDI (Fenson et al., 1994), a checklist where parents are asked to indicate the words that their infant can say. The vocabulary size did not differ significantly between the monolingual (M = 60.85, SD = 56.78, range 8–235) and bilingual groups (M = 58.6, SD = 59.94, range 4–244), $t(56)$ = .885, p = .146, d = .237. Given that this study included a heterogeneous bilingual sample, it was not possible to assess infants' proficiency in their additional language.

2.1.3 | Materials and apparatus

The stimuli consisted of static images of pairs of objects presented on a white background (Figure 1). The objects appeared approximately 10 cm apart and in the centre of the display. These visual stimuli were accompanied by an audio recording intended to direct the infant's attention to one of the objects presented on the screen. Eight images of familiar and unfamiliar objects were selected from the NOUN database (Horst & Hout, 2016). A female native speaker of Australian English was recorded producing the eight target words (*wug*, *lif*, *pok*, *neem*, *cup*, *ball*, *shoe*, *car*) and two carrier phrases ("where is the X?" and "find the X") in infant-directed speech. The carrier phrases and target words were concatenated into the final audio strings that were 6 seconds in duration comprising two phases: the pre-naming phase (silence followed by the carrier phrase up to the target word; total 3 seconds) and the post-naming phase (the target word followed by silence; total 3 seconds).

The visual and audio stimuli were used to create 56 experimental trials. Twenty-eight trials that included the labels *pok*, *neem*, *cup*, and *ball* (and their corresponding visual referents) were assigned to Condition 1. The remaining 28 trials that included the labels *lif*, *wug*, *shoe*, *car* (and their corresponding visual referents) were assigned to Condition 2. Each condition included eight disambiguation trials (familiar object + novel object + novel label), eight familiar label trials (familiar object + novel object + familiar label), eight retention trials (novel object + novel object + novel label), and four filler trials (familiar object + familiar object + familiar label). All the objects included in the retention and filler trials were the same objects that infants saw in the disambiguation and familiar label trials, respectively. Four presentation orders were prepared for each condition by randomizing the order of the trials with the constraint that the disambiguation and familiar label trials were always presented first followed by the retention and filler trials. Infants were randomly assigned to each condition and presentation order.

The visual stimuli were presented on a 22-inch computer monitor, and auditory stimuli were played over loudspeakers located under the screen. Data were collected using a Tobii-X120 eye-tracker via the Tobii Studio software (recordings were made at 120-Hz sampling rate). During the experiment, infants sat on their caregiver's lap approximately 60 cm away from the screen. Caregivers listened to masking sounds over noise-cancelling headphones (sounds constructed by mixing instrumental music and the auditory stimuli from the experiment; Nelson et al., 1995) and were instructed to look down to prevent their gaze from interfering with the eye-tracker's recording. The experimenter observed the infant from an adjoining room via live feed from a webcam placed over the computer screen and directed towards the infant's face. At the beginning of the experiment, a 5-point infant calibration routine was completed. Before each trial, infants were presented with an attention-getter stimulus.

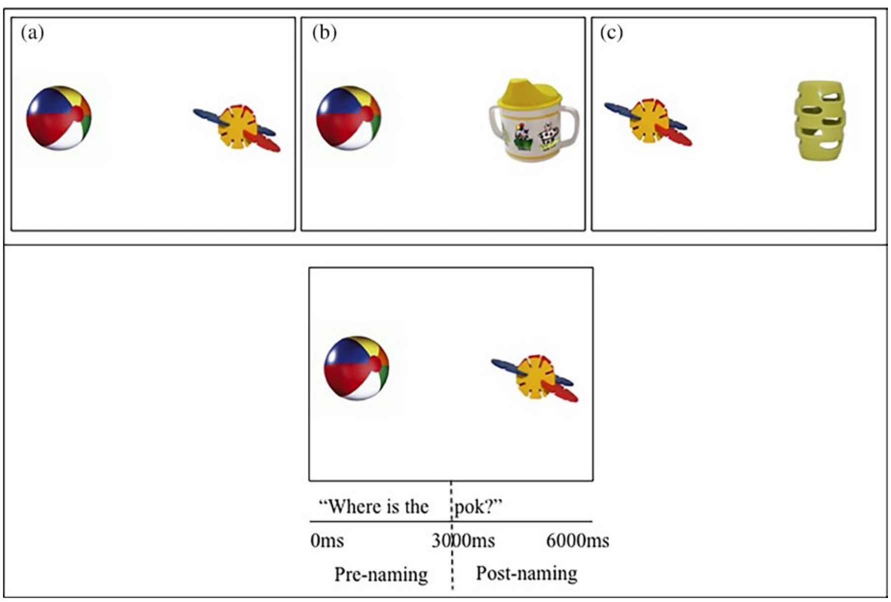

FIGURE 1 Sample visual stimuli for the disambiguation and familiar label (A), filler (B), and retention trials (C) (top panel), and sample structure of the audio-visual stimuli for all trials (bottom panel)

The experimenter controlled the presentation of the trials that only started when the infant fixated the centre of the screen.

2.1.4 | Eye-tracking data analyses

Looking duration (ms) was recorded for the pre-naming and post-naming phases of each trial. Then, the proportion of looking duration to the target object was calculated by dividing the duration of looking duration to the target by the looking duration to the target and the distracter in each phase. Only the trials where the infant fixated on both the target and the distracter in the pre-naming phase were included in the analyses. Given that the retention trials were always presented after the disambiguation trials in this task, infants were included in the final analyses only if they successfully completed the calibration for the eye-tracker and reached the retention phase. Data for the filler trials were excluded from the analyses.

2.2 | Results and discussion

Monolingual and bilingual infants' performance was compared for each trial type (familiar label, disambiguation, retention) by comparing post-naming looking proportion to target to pre-naming looking proportion to target. This analysis allowed us to control for any initial visual preference that infants may have towards the target or distracter objects presented during the task. Following the standard interpretation of looking time data in this paradigm (e.g., Bion et al., 2013; Byers-Heinlein & Werker, 2009), it was expected that if infants selected one of the objects as the referent of the label, their looking duration to the target would be significantly longer in the post-naming compared to the pre-naming phase. Given that infants completed eight trials in each condition, there was a possibility that they could further consolidate the mappings as the task progressed (Mather & Plunkett, 2009). Therefore, infants' performance was also compared across the first and second blocks of the test (first four and last four trials of each type).

2.2.1 | Familiar label trials

In these trials, infants saw a novel object paired with a familiar object and heard the label of the familiar object. A 2(phase) × 2(block) × 2(group) ANOVA yielded a main effect of phase, $F(1, 56) = 5.091$, $p = .028$, $\eta^2 = .083$, indicating that monolingual and bilingual infants directed a greater proportion of fixations to the target object after hearing its label (monolingual: pre-naming $M = .585$, $SE = .018$, post-naming $M = .615$, $SE = .020$; bilingual: pre-naming $M = .579$, $SE = .021$, post-naming $M = .631$, $SE = .024$). There were no main effects of block, $F<1$, or group, $F<1$, and no significant block by group, $F<1$, phase by group, $F<1$, block by phase, $F<1$, or block by phase by group, $F<1$, interactions.

2.2.2 | Disambiguation trials

An identical analysis was conducted for disambiguation trials where infants saw a familiar object paired with a novel object and heard a novel label (Figure 2). The ANOVA showed a main effect of phase, $F(1, 56) = 10.598$, $p = .002$, $\eta^2 = .162$, and no main effect of block, $F<1$. The main effect of group approached significance, $F(1, 56) = 3.739$, $p = .058$, $\eta^2 = .064$, indicating that there was a trend for monolingual infants to attend more to the target in the pre- and post-naming phases than bilinguals. However, importantly, there were no significant phase by group, $F<1$, block by group, $F(1, 56) = 1.382$, $p = .245$, $\eta^2 = .025$, block by phase, $F<1$, or block by phase by group, $F<1$, interactions. In this task, both monolingual and bilingual infants directed a greater proportion of fixation time to the target object after hearing a novel label.

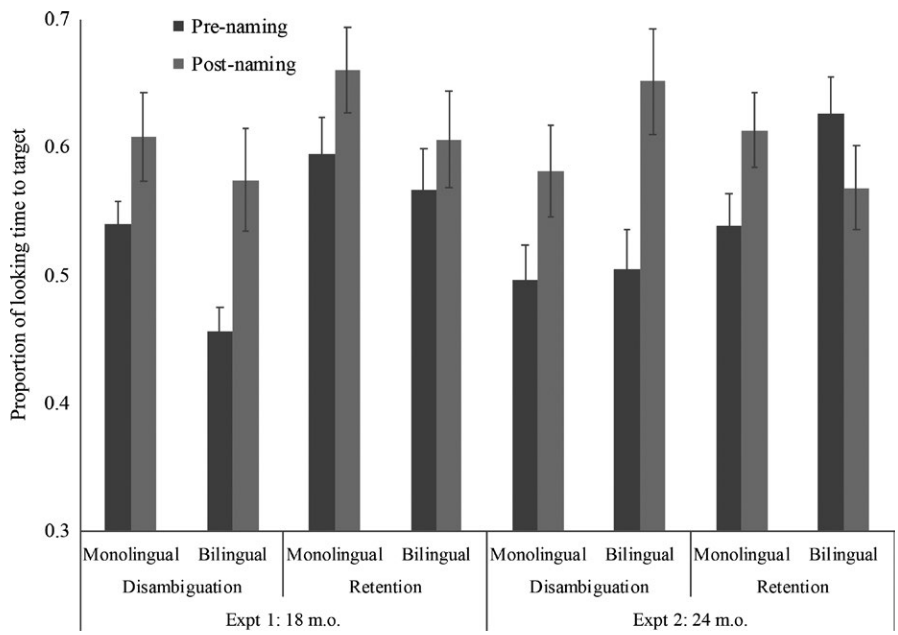

FIGURE 2 Proportion of looking time to the target object in the pre- and post-naming phases by monolingual and bilingual children in Experiment 1 (18-month-olds) and Experiment 2 (24-month-olds) (error bars represent SEM)

2.2.3 | Retention trials

Retention trials presented infants with the two novel objects and the novel labels assigned to these objects in the disambiguation trials. The ANOVA showed an identical results pattern as for the familiar label and disambiguation trials. Infants looked longer at the target in the post-naming compared to the pre-naming phase, $F(1, 48) = 4.256$, $p = .045$, $\eta^2 = .081$ (Figure 2). All other main effects and interactions did not reach statistical significance: block, $F(1, 48) = 1.657$, $p = .204$, $\eta^2 = .033$, group, $F(1, 48) = 1.097$, $p = .300$, $\eta^2 = .022$, block by group, $F<1$, phase by group, $F<1$, block by phase, $F<1$, block by phase by group, $F<1$.

In order to obtain an index of each infant's individual performance in the disambiguation and retention trials, we computed disambiguation and retention scores by calculating the difference between the post-naming and pre-naming phase for each trial type (e.g., Kalashnikova, Mattock et al., 2016). A difference score above 0 indicates that the child showed an increase in proportion of looking time to the target after hearing the target label and thus a greater disambiguation or retention effect (Figure 3). This was the case for 57% (19 out of 33) of monolinguals in disambiguation trials and 63% (21 out of 33) in retention trials. In the bilingual group, 64% (16 out of 25) obtained difference scores greater than 0 in disambiguation trials and 60% (15 out of 25) in retention trials. The individual difference scores were used in correlational analyses, which assessed the relationship between children's performance on the task (both disambiguation and retention trials) and their English vocabulary size. For the bilingual group, we also included bilingual language exposure as an independent variable. As seen in Table 1, in the monolingual group, ME and retention scores were not significantly related to infants' English vocabulary size or to each other. Similarly, in the bilingual group, ME and retention scores did not relate to infants' vocabulary size or to infants' level of bilingualism and percentage

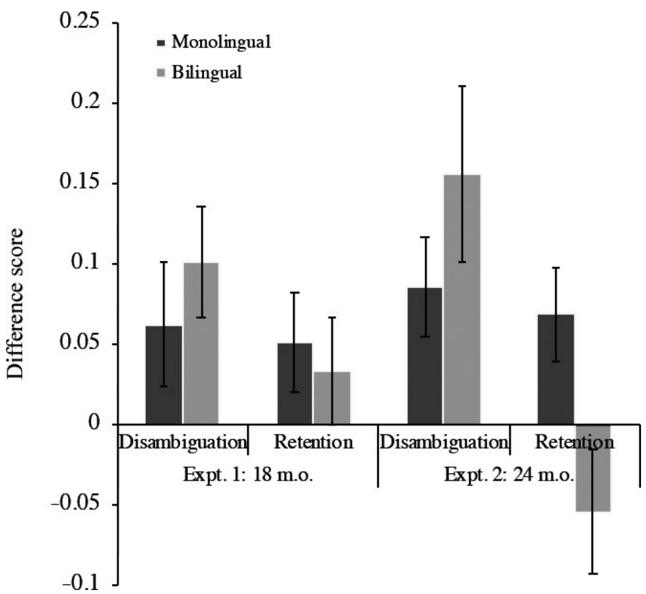

FIGURE 3 ME and retention scores for the monolingual and bilingual children in Experiment 1 (18-month-olds) and Experiment 2 (24-month-olds) (error bars represent SEM)

of weekly English exposure. Interestingly, a lack of significant correlation between the disambiguation and retention scores suggests that the infants who relied on ME in disambiguation trials were not necessarily the infants who showed retention of the labels.

Unlike previous studies investigating the disambiguation effect in bilingual infants (Byers-Heinlein & Werker, 2009, 2013; Houston-Price et al., 2010), Experiment 1 showed no significant differences in monolingual and bilingual performance in this task. Monolingual and bilingual infants demonstrated use of the disambiguation strategy by increasing their looking duration to the novel object after hearing a novel label. Infants also looked significantly longer to the target during retention trials contrary to the previous findings that have not reported retention abilities among 18-month-old infants in a similar task (Bion et al., 2013). This possibly indicates an early precursor for retention, suggesting a transition from attentionally based fast-mapping mechanisms to processes of encoding and retaining the novel mappings. In order to further investigate the developmental path of monolingual and bilingual infants' reliance on ME, Experiment 2 assessed performance in this task in a sub-sample of these participants when they were 24 months of age.

3 | EXPERIMENT 2

3.1 | Method

3.1.1 | Participants

Thirty-two 24-month-old monolingual and bilingual infants participated. All infants had also taken part in Experiment 1. Eighteen infants were from the monolingual group (9 female, $M_{age} = 105.09$ weeks, $SD = 1.06$), and 14 were from the bilingual group (10 female, $M_{age} = 104.93$, $SD = 1.13$). Four additional infants participated but were excluded due to failure to calibrate or to capture sufficient gaze data for analyses. The remaining infants who took part in Experiment 1 and were included in the final sample were no longer available to take part in this study.

Parents of the bilingual children were asked to update their reports of their children's language exposure. At 24 months, children's exposure to English ranged from 20% to 75% ($M = 51.7\%$, $SD = 18.3\%$) and to the other language from 25% to 74% ($M = 46.9\%$, $SD = 17.3\%$). Based on their exposure to the two languages, six infants were dominant in English, five in their additional language, and five infants received balanced exposure to the two languages.

All parents also completed the OZI when their infants were 24 months. Expressive vocabulary for monolingual children was 270.67 ($SD = 133.50$, range 79–491) and 209.93 ($SD = 140.02$, range 6–479) for bilinguals, but this difference did not reach statistical significance, $t(30) = 1.273$, $p = .27$, $d = .01$.

3.1.2 | Procedure

Stimuli and procedure were identical to Experiment 1. Children who completed Condition 1 in Experiment 1 were assigned to

TABLE 1 Correlational analyses for 18-month-old monolingual and bilingual infants' disambiguation, retention scores, English receptive vocabulary, and bilinguals' English exposure

Monolingual			
	Retention	**Expressive vocabulary**	**English Exposure**
Disambiguation	−0.09	−0.196	–
Retention		0.064	–
Vocabulary	–	–	–
English Exposure	–	–	–
Bilingual			
	Retention	**Expressive vocabulary**	**English Exposure**
Disambiguation	0.079	−0.130	0.153
Retention	–	−0.180	−0.348
Vocabulary	–	–	0.253
English Exposure	–	–	–

Condition 2 in Experiment 2 and vice versa to ensure that they were exposed to different visual and auditory stimuli at their two visits to the lab.

3.2 | Results and discussion

3.2.1 | Familiar label trials

Infants' performance was analysed with a 2(phase: pre-naming, post-naming) × 2(block: 1st, 2nd) × 2(group: monolingual, bilingual) ANOVA. For this trial type, the ANOVA yielded a main effect of phase, $F(1, 30) = 6.452$, $p = .016$, $\eta^2 = .177$. Monolingual and bilingual infants directed a significantly larger proportion of looking time to the target object after hearing the target label. There were no main effects of block, $F(1, 30) = 1.807$, $p = .189$, $\eta^2 = .057$, and group, $F<1$, and no significant block by group, $F<1$, phase by group, $F<1$ interactions. The block by phase interaction was significant, $F(1, 30) = 4.810$, $p = .036$, $\eta^2 = .138$. Infants' proportion of looking to target in the pre-naming phase was higher in Block 2 ($M = .670$, $SE = .033$) than in Block 1 ($M = .552$, $SE = .016$), but it did not differ for the post-naming phase (Block 1 $M = .643$, $SE = .028$; Block 2 $M = .646$, $SE = .032$). The three-way block by phase by group, $F<1$, interaction was not significant.

3.2.2 | Disambiguation trials

Similarly to Experiment 1, the ANOVA showed a main effect of phase, $F(1, 30) = 13.806$, $p = .001$, $\eta^2 = .315$, with infants increasing their proportion of looking at target post-naming compared to pre-naming (Figure 2). There was also a significant main effect of block, $F(1, 30) = 7.208$, $p = .012$, $\eta^2 = .194$, suggesting that infants' looking at target increased as the experiment progressed (Block 1 $M = .523$, $SE = .020$; Block 2 $M = .593$, $SE = .026$). The remaining main effects and interactions were not significant: group, $F(1, 30) = 1.141$, $p = .294$, $\eta^2 = .037$, phase by group, $F<1$, block by group, $F<1$, phase by block, $F(1, 30) = 3.004$, $p = .093$, $\eta^2 = .091$, and phase by block by group, $F<1$.

3.2.3 | Retention trials

Unlike the familiarization and disambiguation trials, the ANOVA did not yield a main effect of phase for the retention trials, $F<1$. However, in this case, the phase by group interaction was significant, $F(1, 26) = 6.124$, $p = .020$, $\eta^2 = .191$. As shown in Figure 2, monolingual infants at 24 months significantly increased their looking to the target in the post-naming phase compared to the pre-naming phase, $t(17) = 2.323$, $p = .033$, $d = .475$. This, however, was not the case for bilingual infants, $t(12) = 1.586$, $p = .139$, $d = .520$. The remaining main effects of block, $F<1$, and group, $F<1$, and block by group, $F< 1$, block by phase, $F<1$, block by phase by group, $F<1$, interactions were not statistically significant.

As in Experiment 1, individual disambiguation and retention difference scores at 24 months were computed (Figure 3). In the monolingual group, 72% of children (13 out of 18) obtained disambiguation and retention difference scores above 0. In the bilingual group, 64% (9 out of 14) obtained disambiguation difference scores above 0, but only 29% (4 out of 14) did so in the retention trials. Correlational analyses were conducted separately for each language group to assess relationships between ME and retention scores and infants' language English competence and language exposure patterns at 24 months of age (Table 2). For the monolingual group, no significant correlations were found between ME and retention scores and vocabulary scores. On the other hand, for the bilingual group there was a significant positive association between ME scores and the children's level of weekly English exposure, $r(14) = .648$, $p = .012$.

3.2.4 | ME use at 18 and 24 months of age

The results of Experiment 2 suggest that ME use may follow different developmental trajectories for monolingual and bilingual children. That is, monolinguals' reliance on ME for fast-mapping and retaining

TABLE 2 Correlational analyses for 24-month-old monolingual and bilingual infants' disambiguation, retention scores, English receptive vocabulary, and bilinguals' English exposure (*p = .012)

Monolingual			
	Retention	**Expressive vocabulary**	**English Exposure**
Disambiguation	0.354	0.01	–
Retention	–	0.086	–
Vocabulary	–	–	–
English Exposure	–	–	–
Bilingual			
	Retention	**Expressive vocabulary**	**English Exposure**
Disambiguation	−0.396	0.198	.648*
Retention	–	−0.407	−0.266
Vocabulary	–	–	0.267
English Exposure	–	–	–

novel labels did not differ between 18 and 24 months. On the other hand, bilinguals were shown to rely on ME in disambiguation trials to a similar extent at 18 and 24 months, but they only showed retention at 18 months. However, given that Experiment 2 only included a sub-sample of children from Experiment 1, it is possible that this finding is due to the selection of children who were particularly unsuccessful in the retention of novel labels at 18 and 24 months. The longitudinal design of this study allows for a direct test of this possibility. For this purpose, children's performance in the disambiguation and retention trials was assessed using 2(phase: pre-naming, post-naming) × 2(age: 18 months, 24 months) × 2(group: monolingual, bilingual) ANOVAs including only the sub-sample of children who completed the word-learning task at the two ages. Since the inclusion of block as a within-subjects variable did not yield significant effects in the previous analyses, it was no longer included here.

Disambiguation trials

A significant main effect of phase, $F(1, 30) = 18.827$, $p < .001$, $\eta^2 = .386$, showed that monolingual and bilingual infants directed a significantly greater proportion of looking time at the target object in the post-naming than the pre-naming phase. Children's performance did not differ significantly across age, $F(1, 30) = 1.556$, $p = .222$, $\eta^2 = .049$, or group, $F<1$, and there were no age by group, $F(1, 30) = 1.903$, $p = .178$, $\eta^2 = .060$, phase by group, $F(1, 30) = 3.407$, $p = .075$, $\eta^2 = .102$, age by phase, $F(1, 30) = 1.044$, $p = .315$, $\eta^2 = .034$, or age by phase by group, $F<1$, interactions.

Retention trials

In this case, there were no main effects of age, $F<1$, group, $F(1, 28) = 1.053$, $p = .314$, $\eta^2 = .036$, or phase, $F(1, 28) = 2.627$, $p = .116$, $\eta^2 = .086$. The age by group, $F<1$, phase by group, $F(1, 28) = 2.143$, $p = .154$, $\eta^2 = .071$, or phase by age, $F(1, 28) = 3.692$, $p = .065$, $\eta^2 = .116$, interactions also were not significant, but the three-way phase by age by group interaction approached statistical significance, $F(1, 28) = 4.004$, $p = .055$, $\eta^2 = .125$.

To investigate the source of the three-way interaction, children's performance in retention trials across the two age points was analysed separately for each language group. For the monolingual group, a 2(phase: pre-naming, post-naming) × 2(age: 18 months, 24 months) ANOVA revealed an effect of phase, $F(1, 17) = 4.860$, $p = .042$, $\eta^2 = .222$, but no effect of age, $F<1$, or phase by age interaction, $F<1$, further demonstrating that monolingual children significantly increased the proportion of looking time at target after hearing the target label. On the contrary, for the bilingual group, the ANOVA showed no main effects of phase, $F<1$, or age, $F<1$, but a significant phase by age interaction, $F(1, 11) = 6.390$, $p = .028$, $\eta^2 = .367$, confirming that bilingual infants' performance in the retention trials decreased between 18 and 24 months of age.

The findings from Experiment 2 are consistent with Byers-Heinlein et al. (2014), who found that monolingual and bilingual 2-year-olds reason by exclusivity to a similar extent in disambiguation tasks. However, this experiment also revealed a dissociation in children's emerging ability to retain the mappings established using this strategy. In the retention trials, monolingual infants showed the ability to recognize the referents of novel words that they had previously encountered in referent selection trials, but bilingual infants did not. In addition, at 24 months but not at 18 months, there was a significant correlation between bilingual children's manifestation of the disambiguation effect and the level of their exposure to English. The use of disambiguation was more reliable in toddlers who received greater exposure to English, which may indicate that children's emerging abstract lexical knowledge in each language may relate to the consolidation of ME as a more reliable fast-mapping strategy (Kalashnikova, Mattock et al., 2016).

4 | GENERAL DISCUSSION

The current study assessed monolingual and bilingual children's use of the ME assumption in disambiguation and retention paradigms in a novel between-groups longitudinal design. Experiment 1 showed that 18-month-old monolingual and bilingual children did not differ significantly in the extent to which they relied on ME to disambiguate the referents of novel words and to retain the newly established word–referent mappings. In contrast, the groups showed emergent developmental differences. Specifically, Experiment 2 showed that at 24 months monolinguals and bilinguals relied on ME to a similar extent, but only monolinguals showed the ability to retain the newly mapped labels. These findings inform the developmental path of monolingual and bilingual children's reliance on the ME assumption to fast-map and retain novel labels, whereby children from both language backgrounds show ME by default but only monolinguals later adopt it as a reliable word-learning strategy.

The most significant finding of this study is that bilingual and monolingual children's performance only differed in the retention trials at 24 months of age. It is unlikely that monolingual and bilingual children differed in their overall ability to establish and retain mappings between novel words and their referents (Byers-Heinlein, Fennell, & Werker, 2013; Kan & Kohnert, 2008). Instead, the current data suggest that the underlying mechanisms for the ME assumption in monolinguals and bilinguals diverge across development, with differences emerging between 18 and 24 months of age. While ME is maintained as a reliable word-learning strategy for monolinguals, for bilinguals it may remain solely a default fast-mapping assumption that they use when no further information about the referential meaning of the novel word is available, and which does not necessarily lead to word learning. This explanation also relates to the finding that while preschool-aged monolingual and bilingual children rely on ME to a similar extent, bilinguals become significantly more successful at suspending or violating this assumption when presented with instances of lexical overlap (Davidson et al., 1997; Kalashnikova et al., 2015). That is, for monolinguals, the use of this assumption becomes stronger with age (Kalashnikova et al., 2014, 2015), whereas bilinguals learn that it is not a reliable strategy to learn new word–referent mappings.

The longitudinal assessment of ME use across two ages presented in this study sheds light on the transition of ME from a default assumption in referent selection tasks, which is possibly grounded in general attentional biases (Dysart et al., 2016; Hollich et al., 2000; Pruden et al., 2006; Samuelson et al., 2017), to a sophisticated word-learning assumption or strategy moulded by the child's individual lexical knowledge and linguistic experience. This dynamic view of ME has been postulated for monolingual infants (McMurray et al., 2012; Samuelson et al., 2017; Samuelson & McMurray, 2017), whereby their initial tendency to attend to a novel object when presented with a novel label, regardless of whether a familiar competitor is present or not (Horst et al., 2011; Mather & Plunkett, 2012), becomes more constrained with the growth of their specific (Grassmann et al., 2015) and abstract (Graham et al., 1998; Kalashnikova, Mattock et al., 2016) vocabulary knowledge. This is the first study to show such a developmental progression for bilingual infants. Unlike monolinguals, as bilinguals' language experience increases with age, they commonly encounter instances of lexical overlap in their linguistic environment and expand their own knowledge of translational equivalents, which are instances of lexical overlap across languages. These aspects of bilingual lexical acquisition, therefore, appear to weaken bilinguals' reliance on ME even in tasks that involve only one of their languages (Kalashnikova et al., 2015).

It is noteworthy that two results from this study fail to align with findings reported in previous literature. First, bilingual and monolingual infants' performance did not differ in the disambiguation trials of the word-learning task used here. This is not unexpected for 24-month-olds, as bilinguals have been shown to rely on ME at this age (Byers-Heinlein et al., 2014), but 18-month-old bilinguals were expected to manifest ME to a lesser extent than their monolingual counterparts (Byers-Heinlein & Werker, 2009; Houston-Price et al., 2010). One possibility is that, in contrast to previous research, the bilingual infants in the present study received more exposure to English (the target language in this case) and were more proficient in English than in their additional language. For instance, bilingual children often have smaller expressive vocabularies in each of their languages than monolinguals (Pearson, Fernandez, Lewedeg, & Oller, 1997), but this was not the case in this sample. Thus, it is possible that children's performance in this word-learning task as well as their English vocabulary size were dependent on their individual patterns of language exposure and use rather than solely on the experience of growing up bilingual (MacLeod, Castellanos-Ryan, Parent, Jaques, & Séguin, 2017). In support of this argument, disambiguation use in 24-month-old bilinguals was significantly correlated to their extent of exposure to English. This may indicate that children who receive greater exposure to one of their languages employ disambiguation more reliably. Furthermore, bilinguals' greater exposure and use of English may result in reduced knowledge of translational equivalents, which is a factor that determines bilinguals' individual ME use (Byers-Heinlein & Werker, 2013). Knowledge of translational equivalents was not assessed in this study, but it is possible that, compared to previous studies, the number of translational equivalents was low because only five infants were reported to have balanced exposure to their two languages.

The second unexpected finding concerns the successful retention of the labels learned via ME by monolingual and bilingual children at 18 months of age. While reliable performance in novel word retention tasks has been elicited after 24 months, previous research has shown that adjustments to the experimental paradigm (e.g., shorter delay between learning and retention trials; Horst & Samuelson, 2008) can enhance performance. In this study, infants were presented with only two phonologically distinct novel labels, and the retention trials were completed immediately after the disambiguation trials, which may have facilitated the task for the young children (Kucker & Samuelson, 2012; Spiegel & Halberda, 2011). However, the source for the difference between the present results and Bion et al.'s (2013) findings is unclear since they used a similar experimental task and reported no evidence for retention in 18- and 24-month-old monolingual children. This dissociation calls for further studies aimed to investigate the emergence of the ability to retain novel labels learned via ME, and whether a potential early precursor for this ability can be reliably elicited in young children before 2 years of age.

5 | CONCLUSION

Children bring an array of word-learning strategies to the problem of language acquisition, but crucially, these are likely to be more or less helpful depending on a child's linguistic experience and developmental level. Our findings illustrate that the use of the ME strategy dynamically changes across time, evolving from a default bias, possibly grounded in general attentional mechanisms, into a genuine word-learning strategy across linguistic development. While an early ME assumption is available to monolingual and bilingual infants to solve situations of lexical ambiguity, later use of this assumption to map and retain novel word forms is moulded by children's understanding of the relations between words and their referents and their individual experiences with language acquisition and language use.

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