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Comparison of novel word learning in bilingual and monolingual infants using mutual exclusivity: A systematic review

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Abstract

Research comparing bilingual and monolingual infants on novel word learning tasks using the mutual exclusivity assumption has been inconclusive. To this date, a systematic review on novel word learning comparing the use of the mutual exclusivity bias between typically developing bilingual and monolingual infants in different learning contexts has not been conducted. We, therefore, examined the impact of learning environments on bilingual and monolingual infants' novel word mapping using the mutual exclusivity assumption. Data extraction, quality assessment, and synthesis were performed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines to assess the significance of learning environments in bilingual and monolingual infants' adherence to mutual exclusivity during novel word learning tasks. The search keywords (mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants") were used in four academic databases, namely, PubMed, PsycInfo, Web of Science and Linguistics, and Language Behavior Abstracts (LLBA). The Cochrane guide for intervention reviews was used for the data extraction and risk of bias. Synthesis methods included data tabulation and a textual approach (narrative synthesis) of the selected studies. Records of 143 relevant studies were found, but only four were included in this review based on eligibility criteria. Outcomes suggest that bilingual and monolingual differences and similarities in linguistic learning environments. However, in social contexts, consistency could not be assessed due to the lack of evidence found in this review.

Keywords: mutual exclusivity, disambiguation effect, bilingual infants, monolingual infants, fast mapping, word learning

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1. Introduction

Novel word acquisition in children is a dynamic process. Children swiftly hypothesize word meanings by using biases or assumptions about a new word and its referent. This phase is called fast mapping. Then children slow map the newly acquired word into their long-term memory (Munro, Baker, McGregor, Docking & Arciuli, 2012; Repnik, Chondrogianni, & Sorace, 2021). Children use different learning strategies during fast mapping. One such strategy is mutual exclusivity. Mutual exclusivity facilitates word mapping by creating word categories with mutually exclusive labels. For instance, the word "blueberry" might be considered a category of fruit that has semantically related words such as nouns (e.g., raspberry) and adjectives (e.g., blue). One way to use and maintain mutual exclusivity is by disambiguating new word labels. This disambiguation effect occurs when children effectively discriminate between familiar and unfamiliar labels by providing an unknown label to an unknown object (Figure 1). For instance, a child is presented with a blueberry and a strange fruit. Then, they hear a novel word. Since they can recognize one as blueberry, they immediately assume that the new label belongs to the strange fruit (Merriman, Bowman, & MacWhinney, 1989; Eviatar, Taha, Cohen, & Schwartz, 2018; Kalashnikova, Oliveri, & Mattock, 2019). In contrast to mutual exclusivity, lexical overlap is another technique that facilitates fast mapping of newly acquired words. With this strategy, children use two labels for one familiar word (Kalashnikova, Oliveri, & Mattock, 2019). For instance, children will accept the words kitten and cat for a four-legged animal that meows. These two heuristics, mutual exclusivity and lexical overlap, promote vocabulary development for children overall.

Mutual exclusivity has been primarily used across experiments in linguistic and non-linguistic environments. Linguistic environments include single-object labeling tasks, and cross-situational word learning tasks. In single-object labeling tasks children disambiguate word meanings after having a single exposure to a novel word with a known and unknown object, just as in the blueberry example above. Conversely, in cross-situational word learning, children harness information about the unknown word through multiple exposures to the word at different times. For instance, if a child is introduced to the strange fruit with different items multiple times (the strange fruit, a knife, a blender at dinner; the strange fruit, milk, and cereal at breakfast) accompanied by hearing the novel label, they will end up associating the novel word with the strange fruit because the strange fruit is the only item that is presented repeatedly on every single occasion (Fung & Johnson, 2020). Non-linguistic environments include contextual cues, such as the face of a language speaker or the speaker's eye gaze and gestures

(Kalashnikova, Mattock, & Monaghan, 2016; Yow et al., 2017). These contextual cues have proven successful in helping children maintain mutual exclusivity especially when these cues are performed by speakers who are known to the children.

Monolingual and bilingual children typically employ the mutual exclusivity assumption across different environments to learn new words. Studies on monolingual children's use of mutual exclusivity in linguistic and non-linguistic environments have demonstrated that they consistently accept the mutual exclusivity assumption when presented with a familiar and unfamiliar object. Research on bilingual children, however, has yielded different results. Bilingual children tend to violate mutual exclusivity in linguistic environments because of their unique language experiences. Since they are exposed to two languages, they tend to provide two names for a single item (Halberda, 2003). Thus, using lexical overlap seems to be more valuable for them. In non-linguistic environments, however, they use and maintain mutual exclusivity via referential cues.

Experiments on novel word learning for either monolingual or bilingual children have yielded important data for fast mapping word acquisition (Vlach & Sandhofer, 2012). However, the literature comparing bilingual and monolingual children's differences in employing mutual exclusivity in linguistic and non-linguistic environments has been inconclusive. In linguistic environments, some studies have found that monolinguals performed better than bilingual children in learning and retaining novel words (Alt et al., 2019). Another finding has suggested that monolinguals and bilinguals demonstrate similar novel word acquisition (Eviatar, Taha, Cohen, & Schwartz, 2018). In non-linguistic environments, bilinguals and monolinguals perform equally for the most part, although bilinguals have been more effective than monolinguals in certain conditions (Yow et al., 2017). While a few studies have compared monolingual and bilingual children using mutual exclusivity in both linguistic and non-linguistics contexts, to our knowledge scholars haven't considered the interrelatedness of numerous types of contextual variables (e.g., object labeling and object retention [linguistic] vs. eye gaze direction and selected facial expressions [non-linguistic]) in their experiments.

Similarly, these two factors—linguistic background (monolingual and bilingual) and learning environment (multiple linguistic vs. multiple non-linguistic variables)— have not yet been examined together in infancy. The experiments comparing typically developing bilingual and monolingual infants using mutual exclusivity have only focused on one (e.g., object labels) or some learning variables (e.g., object labels + gestures). As a result, it is unclear whether monolingual and bilingual infants' adherence to the mutual exclusivity assumption is consistent in experiments using a combination of

numerous linguistic and non-linguistic parameters. Also, a systematic review to synthesize the published data across studies to explore infants' consistency in performance across different learning environments has not been conducted. Therefore, we reviewed the current evidence on novel word learning to investigate the impact of learning environments on bilingual and monolingual infants' performance differences in adhering to the mutual exclusivity principle. This review aims to analyze and synthesize the data comparing bilingual and monolingual infants' use of mutual exclusivity in novel word learning to determine whether they consistently exhibit differences in acquiring new words in different learning environments. Knowledge of this topic is crucial to gain a more in-depth understanding of the nature of vocabulary acquisition and development in infants across different learning contexts and to help formulate appropriate assessments and treatment programs for monolingual and bilingual infants with cognitive-linguistic deficits.

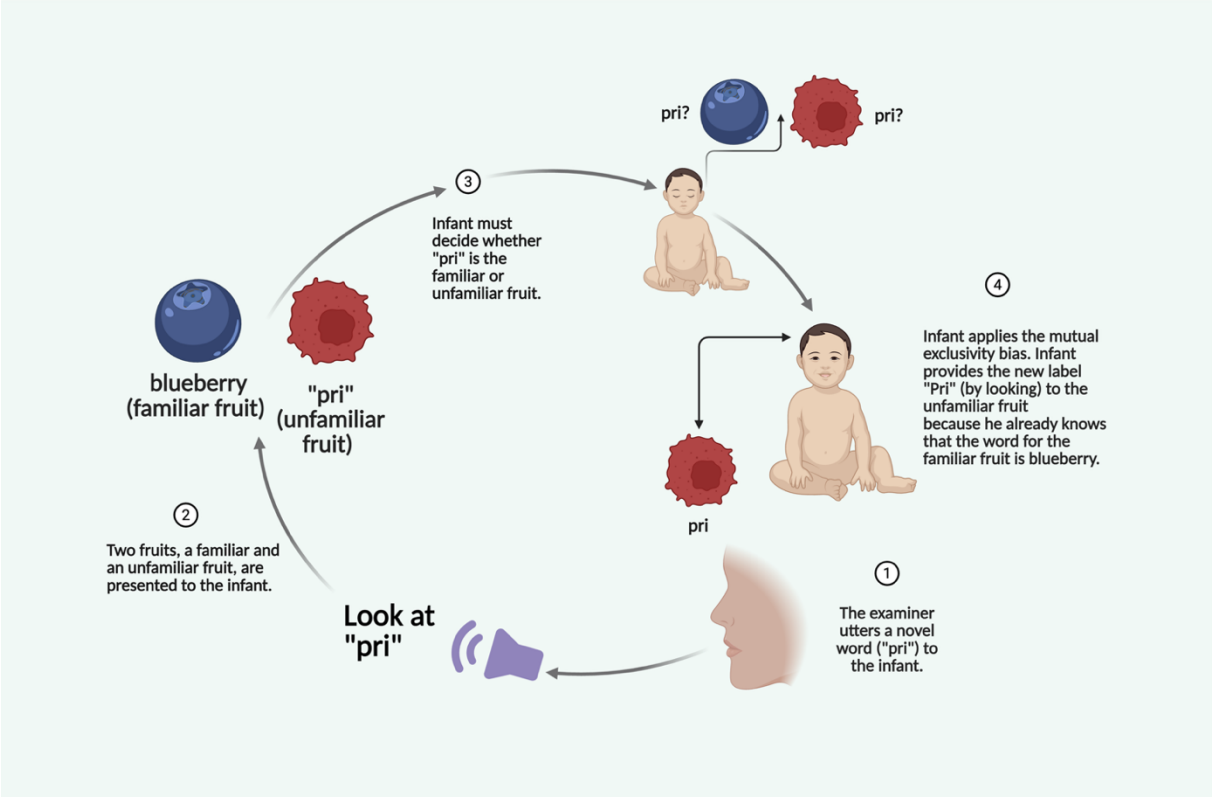

Figure 1. The Mutual Exclusivity Principle in Novel Word Learning. The figure illustrates a typical word learning task using the disambiguation effect of mutual exclusivity. Infants or children accept the unknown label and pair it with the unknown object. Thus, they show mutual exclusivity to the familiar referent. In experimental tasks, children are exposed to visual and audio stimuli to elicit this learning behavior. An eye-tracking device measures the child's fixations or "looking duration" to the items presented during testing. The duration of the child's fixation on the target items is used to determine whether the child associates a novel word with a familiar or

unfamiliar item (Kalashnikova, Escudero, & Kidd, 2018). Created in BioRender. Bodden, R. (2025) https://BioRender.com/kzlcuvn

2. Methodology

2.1. Protocol and Registration

We adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement when conducting this review (Page et al., 2021). Also, a review protocol was submitted for registration at the International Prospective Register of Systematic Reviews (PROSPERO) on February 23rd, 2022, before performing the formal screening of search results. The PROSPERO registration (CRD42022312619) may be retrieved at https://www.crd.york.ac.uk/PROSPERO/view/CRD42022312619

2.2. Search Strategy and Information Sources

A preliminary search, which commenced on 12/2021, was conducted by the first author to identify any relevant literature about our topic. The search keywords ('mutual exclusivity' And 'bilingual and monolingual children') were used in four academic databases, PubMed, PsycINFO, Web of Science and Linguistics, and Language Behavior Abstracts (LLBA). A subject librarian was then consulted several times to help formulate a search strategy for the official search. All authors used the same search strategy-namely (mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants") in the above databases (beginning February 23, 2022) for approximately a week. Based on the results, the authors decided to add two filters to the search strategy, namely, "English" and "infant," to retrieve more relevant results across all databases. Table 1 describes the search process using the selected databases, search strategy, and filters.

Table 1.
Search Strategy for Selected Databases

Search Dates	Databases	Search Terms	Filters and meSH Terms
3/7	PubMed	(mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants")	**Language:** English, **Age:** infant: birth-23 months
3/7	PsycInfo	(mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants")	**Language:** English, **Age:** infant: 2-23 months

3/7	Web of Science	(mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants")	**Language:** English, **MeSH heading:** infant
3/7	Language Behavior Abstracts	(mutual exclusivity OR word learning OR Fast mapping OR disambiguation) AND (bilingual AND monolingual) AND ("infants")	**Language:** English, **Subject:** infant

The search strategy with the selected filters was first used on March 7, 2022. Records yielded from each database were first identified, then harnessed into an Excel spreadsheet. After all the database records were synthesized or compiled, duplicates were removed manually.

2.3. Study Selection and Eligibility

The screening of selected studies began on March 9th, 2022, and continued until the end of the month. All three authors first screened articles based only on the population (infants), scope (mutual exclusivity bias in learning new words), language (English) as well as the type of publication (original research articles) by reading the title and abstract of all selected studies. The rationale behind our choice was that population, scope, language, and the type of publication would retrieve the most relevant articles to our research question. We, for instance, did not focus on the age at this stage since some articles use the word “infant” and “child” interchangeably or inconsistency in age definition-mentioning a specific age, such as 36 months, and the word infant(s) in the title or the abstract. For language, we wanted to prevent reading articles in a language other than English that the database had not detected. A rating for the screening consisted of using a numerical coding system, 2 for unsure, 1 for included, and 0 for excluded. In addition, for all excluded studies, a reason was provided (e.g., wrong population).

The authors then performed the inclusion and exclusion of full texts. Included and excluded studies were determined based on the study characteristics. The same coding system was used to include and exclude the selected articles. We carefully perused each study to identify those that compare our selected population, and the age group selected, 17-23 months. This age group was chosen because at the age of 17 months, English-speaking infants have been observed first to use mutual exclusivity (Halberda, 2003). Also, during this period, monolingual and bilingual infants have already developed solid receptive language skills to identify referents and their labels accurately. Bilinguals in this age range have also developed strong language skills in both languages. According to some research, at 23 months of age, bilingual infants cease learning both languages in a simultaneous fashion (Schulz & Grimm, 2019). Although the consensus is

that children begin learning both languages sequentially after age 3 (Friederici, 2017; Paradis, Genesee, & Crago, 2011), we decided to include infants no older than 23 months because infants between the ages of 24 months to three years undergo different changes in language development, which are usually more heterogeneous than those of the 17-23 months age group. We, therefore, included studies of infants who were more homogenous in their language ability to answer our main research question. Hence, in this review, we classified the bilingual age group as early simultaneous bilinguals, ages 17-23 months. Excluded articles were based on more specific study characteristics and idiosyncrasies of studies.

All reviewers involved independently searched and screened for records based on the inclusion criteria during the search process. Discrepancies in results were solved in research meetings, whereas authors first discussed their outcomes and thereafter reached a consensus.

2.4. Data Extraction and Quality Assessment

Data was extracted using the Cochrane form for intervention reviews for RCTs and non-RCTs as a model (Jpt, 2008). All authors first piloted two studies, each creating a different table of the included studies' characteristics. After selecting data items from each article, they reached a consensus and extracted pertinent data, namely the components and populations' characteristics, from the included studies.

The Cochrane risk of bias tool, namely ROBINS-I (Sterne et al., 2016), was used to measure the risk of bias among the chosen articles for this review. This tool is appropriate for experimental studies that do not include a control group but use a pseudo-randomization method such as the one used in the four included studies.

3. Findings

3.1. Data Outcomes

Outcomes of our systematic search revealed that of the 143 records retrieved, 16 were assessed for eligibility. Out of these 16 studies, only 4 studies met our inclusion criteria. In the identification phase, 143 articles were initially selected, and 49 duplicate records were manually removed. The records were screened using the title of the article and the article's abstract, which totaled 94. All the full texts searched for were retrieved and then underwent a final screening. Figure 2 provides a comprehensive summary of the included studies' identification, retrieval, and selection.

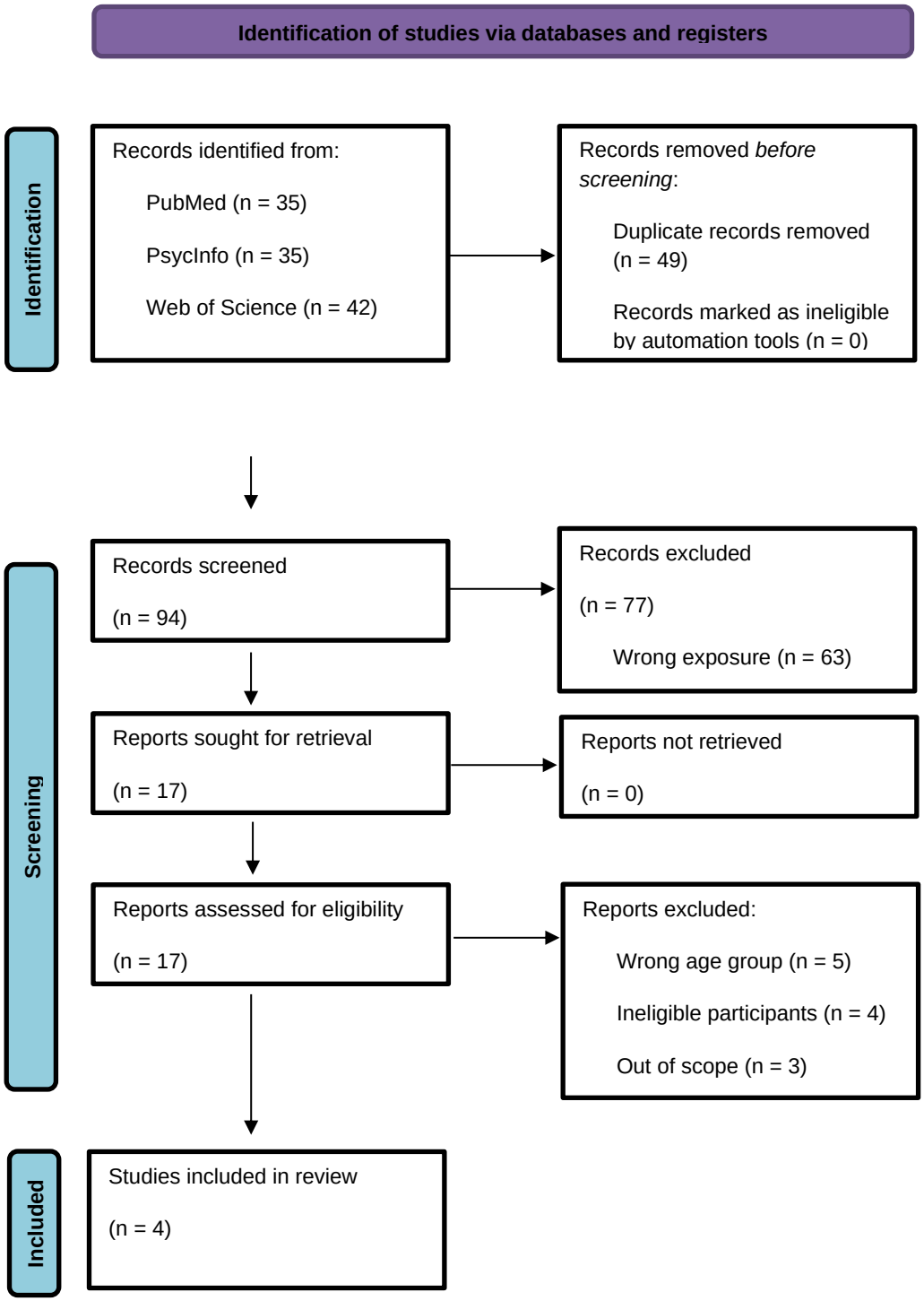

Figure 2. Systematic search of all databases and results using PRISMA guidelines. This comprehensive search resulted in four studies based on established inclusion and exclusion criteria

3.2 Synthesis of Results

A narrative synthesis was used to analyze the data presented in this review. This synthesis included a content analysis comparing the study characteristics, groups (bilingual and monolingual infants), and outcomes. A Data tabulation approach (Jpt, 2008) was also used to illustrate similarities

and differences among the four studies' characteristics—including exposure and learning contexts—population groups, and a summary of reported statistical values.

The four included studies presented in this review used similar study components. Each study used an experimental within-subjects design and utilized a between-subjects variable to compare the groups' performances across tasks. For instance, Weatherhead, Kandhadai, Hall, and Werker (2021) used a different methodology by including more variables, such as the speaker's face, as their study assessed whether the mutual exclusivity assumption was used in a non-linguistic environment. All study components were color-coded (Table 2) for data comparison. The elements coded with the same color represented the similarities shared by each study component.

Regarding the studies' populations, participants from the selected articles showed similar characteristics. The participants consisted of monolingual-English infants and bilingual-English-and-another-language-infants. Language exposure for monolinguals was constant among studies. For bilinguals, however, some studies classified participants as bilinguals with different language exposure criteria and different assessment tools for such classification. Table 3 highlights the similarities and differences found in both population groups' characteristics.

The weight of the evidence was based on the comparison of observed main effects of target variables on specific tasks using a tabulation of the reported statistical values across the four studies. Results suggest that mutual exclusivity is used differently by monolingual and bilingual infants, ages 17-23 months, across learning environments. For instance, Houston-Price, Caloghiris and Raviglione (2010) and Kandhadai, Hall, and Werker (2017) reported that bilinguals did not adhere to the mutual exclusivity principle in the learning tasks presented. Monolinguals, however, used ME in all learning environments. Table 4 summarizes the reported outcomes comparing monolingual and bilingual infants using various statistical analyses.

Table 2.

A summary of the components' characteristics of included studies

Study	Study type	Study Setting	Participants	Learning Conditions	Learning Tasks	Statistical Methods	Measurements
Houston-Price, Caloghiris and Raviglione (2010)	Experimental Within Subjects Design- Counterbalancing Between subjects Variable-comparison of bilingual vs. monolingual groups	Lab setting	Monolingual & bilingual Infants	Visual & auditory stimuli (1) Practice Trial- 1 trial (2) Known Target, Known Distracter Trial-12 trials (3) Known Target, Unknown Distracter Trial- 6 trials (4) Unknown Target, Known Distracter Trial-6 trials	Preferential Looking Task	2 (trial type) x 2 (phase x ANOVA	Ey fixations
Kalashnikova, Escudero and Kidd (2018)	Experimental Within Subjects Design- counterbalancing Between subjects Variable-comparison of bilingual vs. monolingual groups	Lab setting	Monolingual & bilingual Infants	Visual & auditory stimuli 56 trials (28 trials for each condition)	(1) Familiar Label Trials (2) Disambiguation Trials (3) Retention Trials	2 (phase) x 2 (block) x (2 (group) ANOVA	Eye fixations
Kandhadai, Hall and Werker (2017)	Experimental Within Subjects Design- counterbalancing Between subjects Variable-comparison of bilingual vs. monolingual groups	Lab setting	Monolingual & bilingual Infants	Visual & auditory stimuli (1) Familiarization Phase- 5 reps x 3 trials (2) Test Phase- 2 trials novel label= 1 across-category, 1 within-category + 2 trials familiar label	Familiar Label Test, Across-Category Novel Label Test, Within-Category Novel Label Test	Two sample t-tests	Eye fixations
Weatherhead, Kandhadai, Hall, and Werker (2021)	Experimental Within Subjects Design- counterbalancing Between subjects Variable-comparison of bilingual vs. monolingual groups	Lab setting	Monolingual & bilingual Infants	Visual & auditory stimuli (1) Familiarization Phase- 5 reps x 3 trials (2) Test Phase- 4 trials novel label= 2 across-category, 2 within-category + 2 trials familiar label	Familiar Label Test, Across-Category Novel Label Test (Unfamiliar + Familiar Race), Within-Category Novel Label Test (Unfamiliar + Familiar Race)	Univariate ANOVA One-sample t-tests	Eye fixations

Table 3.

A summary of the population characteristics of included studies

Comparison Groups											
		Monolingual Infants					Bilingual Infants				
Study	**Country**	**N**	**Mean Age**	**Gender**	**Language**	**SES**	**N**	**Mean Age**	**Gender**	**Language (s)**	**SES**
Houston-Price, Caloghiris and Raviglione (2010)	UK	30	20 months	Female: 17 Male: 13	English	Middle class or lower middle class	20	20.4 months	Female: 11 Male: 9	English, Afrikaans, Arabic, Czech, Dutch, French, German, Gujarati, Mandarin, Portuguese, Slovak, Spanish, Tagalog, Twi	Middle class or lower middle class
Kalashnikova, Escudero and Kidd (2018)	Australia	33	18 months	Female: 17 Male: 13	English	Upper middle range	25	18 months	Female: 16 Male: 9	English, Cantonese, Mandarin, Vietnamese, Tigrinya, Tamil, Arabic, Korean, Spanish, Russian, Greek, Hindi, Afrikaans	Upper middle range
Kandhadai, Hall and Werker (2017)	Canada	17	17 months, 26 days	Female: 9 Male: 8	English	Data not found	16	17 months, 27 days	Female: 8 Male: 8	English, German, Cantonese, Spanish, Hungarian, Japanese, Punjabi, Portuguese, French, Swedish	Data not found

Weatherhead, Kandhadai, Hall, and Werker (2021)	Canada	48	18 months, 5 days	Female: 20 Male: 28	English	Data not found	48	18 months, 1 days	Female: 22 Male: 26	English, Spanish, Mandarin, Punjabi, Cantonese, French, German, Russian, Polish, Tamil, Korean, Danish	Data not found

Abbreviations: N, number of participants; SES, Social Economic Status

Table 4.

Data synthesis of monolingual and bilingual group performance comparison of included studies

Monolingual and Bilingual Group Performance Comparison			
Study	Learning Trials	Statistical Values Main Effects of Attention to Stimuli within Trials	Outcomes
Houston-Price, Caloghiris & Raviglione (2010)	*Preferential Looking*	F(1, 48) = 5.95 p = .018	Monolinguals applied the ME principle while bilinguals violated the principle.
Kalashnikova, Escudero & Kidd (2018)	*Disambiguation Trials*	F(1, 56) = 1.382 p = .245 (Block by group)	Monolinguals and bilinguals both applied the ME principle.
Kandhadai, Hall & Werker (2017)	*Across-Category Novel Label*	t(28) = 3.01 p < .01 d = 1.13	Monolinguals applied the ME principle. Bilinguals, however, violated the principle.
Weatherhead, Kandhadai, Hall, & Werker (2021)	*Across-Category Novel Label*	F(1, 91) = 0.782 p = .379 (for monolingual and bilingual infant responses)	Monolinguals and bilinguals both applied the ME principle.
	Within Category Novel Label	F(1, 91) = 0.05 p = .816 (for Language and Speaker Race interaction)	

		F(1, 89) = 0.65 p = .422 (for monolingual and bilingual infant responses) F(1, 89) = 0.28 p = .598 (for Language and Speaker Race interaction)	

Note. Studies compared both groups' performance using t-tests and Analysis of Variance (ANOVA) to measure looking direction to target items during word learning tasks. Each value (e.g., F(1, 48) = 5.95, p = .018) represents the main effects of the variables measured. Thus, monolingual groups accepted ME on all tasks presented in the four included studies. However, bilingual groups rejected the assumption of ME on specific tasks in two out of the four studies included in this review.

3.3 *Risk of Bias Assessment*

All authors performed the quality assessment individually, and disagreements were solved in research meetings by discussing outcomes and reaching an agreement.

The research team assessed various bias domains, including selection and confounding biases. Figure 3 provides an overview of all the items tested for the included studies.

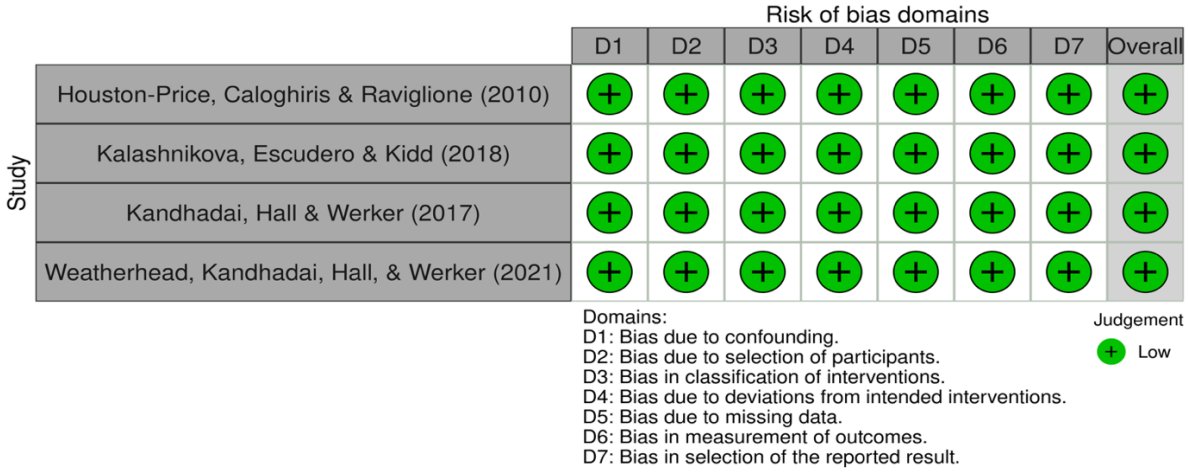

Figure 3. Critical appraisal of four included studies in the review.
A summary traffic light plot figure demonstrating the seven domains used to measure the risk of bias of the included quasi-randomized experiments. An overall score was provided for each domain assessed. All authors concluded that the selected studies are analogous to a true experiment as they showed a low risk of bias in all domains

4. Discussion

This study aimed to identify whether bilingual and monolingual infants use the mutual exclusivity assumption differently across numerous learning environments when learning new words. It was hypothesized that typically developing monolingual infants would consistently outperform bilingual infants, and bilinguals would consistently exhibit less adherence to this principle than monolinguals across studies using multiple linguistic and non-linguistic learning variables.

Results revealed that monolinguals did not consistently outperform bilinguals in linguistic environments. Bilinguals relatively adhered to the ME assumption as monolinguals to some extent. In non-linguistic contexts, consistency in monolinguals' performance could not be measured due to the lack of research on this type of learning parameter. However, a revelation in the study was that monolinguals' performance did not surpass that of the bilingual infants in linguistic environments across all selected studies.

Outcomes of this review were compared with those of previous research on novel word learning. The data identified in our four included studies validates that the mutual exclusivity principle used by infants in linguistic environments is mixed (Kalashnikova, Escudero, & Kidd, 2018). Although both bilinguals and monolinguals show similarities in their performance using the ME strategy in non-linguistic environments as per one study, consistency could not be evaluated due to the limited number of studies that met our inclusion criteria.

This finding contradicts previous research that has suggested that bilinguals tend to violate the mutual exclusivity principle in linguistic tasks (Frank & Poulin-Dubois, 2002). This unanticipated outcome might be due to the extensive vocabulary size of bilingual speakers in English. Regarding non-linguistic contexts, it is plausible that both types of learners would succeed similarly in adhering to the mutual exclusivity principle based on one finding. Thereby, studies that use this type of methodology should be replicated to ensure consistency in outcomes.

This review found that both bilingual and monolingual speakers employed ME inconsistently in linguistic learning environments. It shows that vocabulary size in one language, namely English, can influence outcomes, as shown in one of the included studies in this review. For non-linguistic environments, similar results demonstrate that bilingual and monolinguals can both use ME effectively. Our outcomes, however, should be interpreted with caution as only four articles were eligible for this study. Thus, further research should be undertaken to effectively investigate the effects of both environments on bilingual and monolingual performance on novel word learning tasks using mutual exclusivity.

Regarding the language background of participants, future empirical studies should use more reliable assessment tools to measure the exposure to language in bilingual infants. As previously explained, vocabulary size can impact the performance of bilingual infants in these learning tasks. Thus, appropriate language exposure tools would ensure precision of the amount of language experience bilingual infants receive from their parents or caregivers, especially in their first language.

Experimental designs involving independent measures should be considered for future studies. Comparing two different exposures, such as mutual exclusivity and lexical overlap among monolingual and bilingual infants of the age group examined in this review, would yield interesting findings on how both groups of infants' preferences in strategy selection vary across learning contexts. Also, experiments using bilingual participants should consider selecting participants from the same linguistic background. Because languages tend to differ in vocabulary size and grammatical complexity, scientists should select participants exposed to a specific set of

two languages instead of the various language combinations used by the participants in the included studies of this review.

This review's main strength was presenting systematic evidence comparing monolingual and bilingual infants' language acquisition across different types of environments when learning new words. This study has also explored consistency in performance by these two populations in diverse environments using multiple learning variables.

Regarding limitations, this review used heterogeneous samples-namely, participants from different countries, which might have affected the homogeneity of data outcomes. Second, this study included numerous languages as the other language spoken by bilingual speakers. Although the age range selected was homogeneous, language differences exist among different speakers. Third, the assessment methods used to gauge the participants' language exposure lack uniformity. Also, all monolingual and bilingual infants' linguistic competence was only measured in English, thus potentially affecting how the samples of bilingual infants were represented in each study. Last, this review included variability of socio-linguistic aspects of language learning, which could have been potential confounders.

5. Conclusions

This systematic review revealed that monolingual and bilingual infants use mutual exclusivity inconsistently in linguistic learning environments. In a non-linguistic environment, however, consistency of ME adherence could not be determined due to the lack of published studies using this type of learning context. Thus, research comparing bilingual and monolingual infants using mutual exclusivity across contexts such as those discussed earlier is necessary. By measuring consistency in the performance of ME adherence in various learning environments, the nature of word learning in early language learners could be better explained. To determine which learning environment or environment best facilitates word learning for infants would help increase the number of vocabulary words in typically developing infants and help create early intervention programs to improve the vocabulary skills of those infants with cognitive-language impairments.

Author contribution statement:

Author 1: Project leader/creator of this study: Formulated hypothesis, reviewed/screened articles, collected and synthetized data, performed quality assessment of selected studies and wrote and revised the manuscript.

Author 2: Reviewed/screened articles, collected data and performed quality assessment of selected studies.

Author 3: Reviewed/screened articles, collected data, and performed quality assessment of included studies.

The usage of GenAI: GenAI was not utilized to conduct this research or to write this manuscript.

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