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Research Note

Language-Fair Fast Mapping and Mutual Exclusivity Tasks for Mono- and Bilingual Preschoolers

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ABSTRACT

Purpose: Both monolingual and bilingual children use learning constraints and heuristics to acquire new words from their environment. Overall, fast mapping abilities seem to be similar in both populations, but monolinguals rely more than bilinguals on the mutual exclusivity strategy. Our study probes the robustness of these results in a large group of children learning different language combinations, with a newly devised language-fair task that relies as little as possible on previous linguistic knowledge, in order to avoid disadvantaging bilingual children.
Method: We tested 138 3- to 5-year-old mono- and bilingual children in their dominant language (German, French, Italian, or Turkish) in a computerized task starting with a fast mapping phase, followed by a mutual exclusivity phase, using only invented nonobjects and nonwords.
Results: As hypothesized, monolingual and bilingual children showed similar results during the initial fast mapping stage, but monolinguals relied significantly more on the mutual exclusivity strategy than their bilingual peers.
Conclusions: The language-fair design of our task supports the idea that differences in mutual exclusivity strategy use between mono- and bilingual children really stem from their specific linguistic background, and not from potential familiarity differences with respect to the test words. We discuss the implications of our results for bilingual language assessment in clinical or educational contexts.
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In our society, more than 60% of children grow up in multilingual contexts (survey conducted in 29 European countries by the Associated Press, 2006, cited by Marian & Shook, 2012) and become multilingual speakers, defined as using two or more languages in everyday life (following Grosjean & Li, 2013). These children face the challenge of developing their communication abilities in two or more languages at the same time, sometimes in different contexts (home, day care, etc.). Focusing on lexical development, the first milestones are very similar in monolingual and bilingual[1] children, with first words appearing between 12 and 18 months of age (Paradis, 2011). Bilinguals' total conceptual vocabulary, that is, the number of meanings for which they have a word in any of their languages, is largely the same (Legacy et al., 2018) or even exceeds (De Houwer et al., 2014) that of monolinguals in the first 2 years. However, several studies have shown that developmental trajectories are not the same according to linguistic status (monolinguals vs. bilinguals) and exposure patterns, especially in the case of vocabulary. Thordardottir (2011), for instance, reports significant vocabulary level differences between monolingual and bilingual 5-year-olds that are heavily dependent on exposure patterns. Finally, many other factors beyond linguistic status, be it child-internal characteristics such as verbal memory or nonverbal reasoning, or external characteristics of the child's environment, such as parental education level or the nature of the languages involved, also influence language development trajectories (Paradis, 2019).

In this research note, we aim to show that beyond such quantitative differences in the number of known

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[1] Although learning two or more languages may present many similarities, most acquisition studies, like our own, have focused on bilingual development. To avoid overgeneralizations, we will thus use the term *bilingualism* in the following sections instead of *multilingualism*.

lexical entries, the specific characteristics of mono- and bilingual development lead children on different learning paths when acquiring new words in ambiguous situations, resulting in qualitative differences in the strategies they use. Unlike previous work, we will examine word learning in a language-fair task that does not rely on previous linguistic knowledge at all, in order to avoid disadvantaging bilingual children because of their potentially weaker lexical skills in their respective languages compared to monolinguals. We will present such a task to a large group of preschoolers learning different languages and language combinations.

Word and Object Associations: Fast Mapping

One crucial skill in the acquisition of new words is the ability to associate a new phonological word form, once it is segmented from the speech stream, with its meaning (e.g., an object, action, or characteristic). It usually only takes a few presentations for a new word to be "fast-mapped," that is, memorized with at least a rudimentary meaning (Carey & Bartlett, 1978). Equivalent "fast mapping" skills have been documented in monolingual and bilingual infants from the age of 14 months (Byers-Heinlein et al., 2013). Studies by Kan and Kohnert (2008, 2012) also show that, in bilingual children, fast mapping is as efficient in one language as in the other. However, typically, studies do not directly compare the efficiency of this learning process between bilingual and monolingual children (but see Skoruppa, 2019), focusing instead on the strategies that children use to decide between different possible meanings of new words.

Strategies and Heuristics: Mutual Exclusivity

Indeed, in everyday life, a "pure" and unambiguous learning situation, in which one single new word is repeated in the context of one single new object, is rare. Faced with the multitude of stimuli that surround them, children use different strategies in order to establish new form-meaning mappings efficiently. To do this, they rely on preconceptions, also called heuristics, which are defined as intuitive, spontaneous, and global strategies for assigning meanings from around 18 months of age (Markman, 1991; Markman & Hutchinson, 1984). Note that these preconceptions need not necessarily be correct and can be overridden by evidence to the contrary.

Among several kinds of heuristics, the word learning strategy most studied in the bilingualism literature is the mutual exclusivity heuristic. This strategy consists in considering that each object only needs to have one name and, therefore, assuming that a new word will refer to a previously unknown object, not to an object for which the child already knows a label (e.g., Markman & Wachtel, 1988). While this strategy is very marked in monolingual children, bilingual children rely less on this process (Bialystok et al., 2010; Byers-Heinlein et al., 2013; Byers-Heinlein & Werker, 2009). Byers-Heinlein and Werker (2009) suggest the knowledge of *one-to-one* form-meaning mappings in monolinguals versus *many-to-one* mappings in bilinguals as a plausible explanatory hypothesis. Monolingual children would largely be able to rely on the knowledge that each object should only be designated by one word (except for the rare cases of synonyms). Bilingual children, on the other hand, would be much more familiar with the idea that an object can be designated by two different words across their different languages. They know so-called "translation equivalents" from the beginnings of word acquisition (De Houwer et al., 2006), that is, several different words designating the same concept; for example, *chien* in French and its equivalent *dog* in English.

The effect of bilingualism on mutual exclusivity usage can even be described on a continuum. As shown by Byers-Heinlein et al. (2013) in bilingual English–Chinese children aged 17–18 months, children who know translation equivalents for more than half of the words in their repertoire used the mutual exclusivity strategy even less than their bilingual peers with less balanced language skills. Finally, Byers-Heinlein and Werker (2009), using a preferential look design, showed that in 17–18 months old children again, the use of mutual exclusivity depended on the number of languages being learned: monolinguals used more than bilinguals and trilingual children seemed to have almost no recourse to this strategy. We can, thus, see that mutual exclusivity use is not all-or-nothing, but varies according to language exposure and balance between language skills. Studies in older children (Bialystok et al., 2010; Davidson et al., 1997) confirm that significant differences in mutual exclusivity use between monolinguals and bilinguals were still present at preschool age, and also reveal that age can influence mutual exclusivity usage. Both studies also found interactions between age and bilingualism: Mutual exclusivity usage increases earlier in monolinguals than in bilinguals.

To date, the majority of studies have evaluated mutual exclusivity by making children choose the meaning of a new word form among an array of one unfamiliar or unknown object and several familiar objects, whose names are assumed to be known. However, this type of procedure is problematic if one wishes to make a fair comparison between monolingual and bilingual children, due to the differences in vocabulary knowledge detailed above (e.g., Thordardottir, 2011). In a task using real words, there is a particular risk that words that are considered to be known to monolingual children may not be known, or less well known, in the bilingual group. As a consequence, with such a paradigm, it would be speculative to make conclusions following children's choices. For instance, in the case of a bilingual child pairing a supposedly known object with the new word form, one cannot be sure if this

child was attributing a second label to this object, thus ignoring mutual exclusivity, or if they did not know the label for that object before and were thus using mutual exclusivity by choosing an unknown referent.

Faced with this problem, we propose a new paradigm to evaluate fast mapping and mutual exclusivity skills in an equitable way among children from most language backgrounds. We use only nonwords and nonobjects for this purpose, thus guaranteeing an equivalent "zero" starting level for all children. In this combined procedure, we first ensure that all children have successfully fast-mapped new labels for two unknown objects, which will then serve as distractors in our mutual exclusivity task. This innovative task design will give us a chance to see how children behave with totally new words that they have no chance to be familiar with.

Based on previous studies showing successful fast mapping in monolingual and bilingual children (Byers-Heinlein et al., 2013; Kan & Kohnert, 2008; Skoruppa, 2019), we expect similar performances between these groups in the fast mapping part of our task.

If the differences in mutual exclusivity usage observed in previous studies with familiar words and objects (Bialystok et al., 2010; Byers-Heinlein & Werker, 2009, 2013) are real, and not just a result of word familiarity differences, we expect, however, that monolingual children will perform better than bilingual children when they have to identify an object using the mutual exclusivity strategy, even in a language-fair task as the one we created here.

Method

Our study is part of a pilot study for a larger, longitudinal research project conducted by four universities in Switzerland and Germany. The tasks presented here were included in a comprehensive protocol evaluating language, cognition, and metacognition as well as social–emotional development, which has been evaluated as unobjectionable by the regional ethical committee Ethikkommission Nordwest- und Zentralschweiz (EKNZ; Req-2020-00504). Our task, like most others in this protocol, was computerized.

Participants

In the following, we present data from 138 participants, 66 boys (43 monolinguals, 23 bilinguals) and 72 girls (50 monolinguals, 22 bilinguals), from 35 to 66 months (M = 50.6 months, SD = 6.7 months; see Table 1). Among these children, 93 were monolingual (71 German-speaking, 22 French-speaking) and 45 bilingual (29 German–Turkish, eight German–Italian, and eight French–Italian). All children were growing up in German-speaking or French-speaking societies. The vast majority of our participants were White Caucasian.

Table 1. Descriptive statistics of participants with mean and standard deviation.

Group	Age in months	Parental education	Nonverbal reasoning
Monolinguals	49.27 (6.10)	6.74 (0.71)	10.53 (3.06)
Bilinguals	53.29 (7.13)	5.69 (1.54)	11.17 (3.11)

As we wished to consider bilingualism on a broad continuum, we chose to use a lower cutoff than previous studies (e.g., Pearson et al., 1997). Children were considered bilingual if they had been exposed to a home language (i.e., Turkish or Italian) that was different from societal language (i.e., German or French) for at least 8 hr a week (which is equals about 10% of the awake time, that we estimated at 84 hr a week at this age) and for more than 3 months. They were considered monolingual if the exposure to any other languages was below this criterion. Children exposed to more than two languages were excluded from the study. This language background information was obtained during a preliminary telephone interview where the parents were asked how often the child was using one or the other language within the family and the day care center. We then determined the percentage of time the child used one language or the other based on these estimates and the length of time the child attended the day care center. The average exposure time to home language from our bilingual participants was 43 hr 11 min a week (SD = 18 hr 16 min, range: 9 hr 25 min to 75 hr a week). Also, to determine the dominant language for our testing session, we asked parents in which language the child was most able to express him/herself, among societal language or home language. Thus, 16 (35.6%) bilingual children were dominant and tested in the societal language, and 29 (64.4%) were dominant and tested in their home language. That means that in the end, 86 children were tested in German,[2] 23 in French, 19 in Turkish, and 10 in Italian.

These children were recruited through contacts with preschool child care facilities, by advertisement on social networks and word of mouth in Switzerland and Germany. Their parents (or legal guardians if applicable) gave their free and informed consent, via a detailed form, to participate in this project, as stipulated by local research ethics rules.

Materials

We created two target words for the fast mapping task (/deti/ and /dapu/) and three for the mutual exclusivity part (/pato/, /kebi/, /nuba/), as well as a practice item (/todo/). All were bisyllabic nonwords of a quasi-universal consonant–vowel–consonant–vowel structure, and contained only sounds existing in all test languages. They were

[2]High German: n = 20, Basel dialect: n = 30, Bern dialect: n = 36.

recorded in carrier sentences (see full list in all four languages in Supplemental Materials S1 and S2) by female native speakers of the four languages and two dialects (French, German, Italian, Turkish, as well as Bernese Swiss-German and Basel Swiss-German). Eight nonfigurative objects were drawn especially for the task (see examples in Figure 1 and the full list in Supplemental Materials S1 and S2).

Procedure

The task was presented as a game in which a small crocodile on a beach wanted to show his toys to the child, and then requested them to select one of them (see example of a fast mapping test trial in Figure 1). It was run on a touch tablet (HP Pavilion x360 14-cd0603ng, 14″ screen) via the Inquisit 5 software (Millisecond, 2018). The task was presented in the child's dominant language, as indicated by the parents in the preliminary interview. It lasted about 2 min, but was embedded in one of two larger testing sessions of about 1.5 hr each. The order of the tasks in the overall study was counterbalanced according to four randomizations.

Although presented as a single game to the child, the task was divided into several subparts: the very first part of it was a practice trial. The child saw a single novel object on the beach and heard the crocodile's voice saying, "Look, this is a /todo/. Can you please give me the /todo/? Press on it so that it comes to me!" There was no time limit. The experimenter waited for the child to understand how to proceed and, if necessary, repeated the instruction or even the whole practice trial. Upon success, they entered the "fast mapping" part.

Fast Mapping

During the exposure phase, a first object A (see rightmost object in Figure 1), the /deti/, was presented on its own and its name was used 3 times by the crocodile: "Look, this is a /deti/. The /deti/ is nice. I really like playing with the /deti/." This process was repeated for a second object B (see leftmost object in Figure 1), the /dapu/: "And this is a /dapu/. I like the /dapu/ a lot too. I really like the /dapu/." The names of the objects were phonologically distant and the objects were visually distinct (see the full list in Supplemental Materials S1 and S2).

Figure 1. Sample screenshot of a fast mapping test trial. In this randomization, the leftmost object is the /dapu/, the rightmost the /deti/, and the middle ones are distractors.

During the subsequent test phase, the child then saw four objects appear, among which were A and B and two new nonfigurative drawings as distractors (see Figure 1, middle). The positions of the objects were randomized. The crocodile then asked the child to first select the /deti/ ("Can you give me the /deti/, please? Please, show me the /deti/.") then the /dapu/ ("Please, now give me the /dapu/. Please, show the /dapu/.").

In case of an error in the designation of at least one of the two objects, the exposure-test process was repeated as the first time. Again, a successful trial led to the next phase, while an error caused the exposure-test cycle to repeat itself. In this third cycle, the instructions were automatically played twice in a row, thus totaling six occurrences of each nonword. As soon as the child learned the two new nonwords, they proceeded to the "mutual exclusivity" phase detailed below. If, after three cycles, they still failed to learn one or both words, the task ended.

Mutual Exclusivity

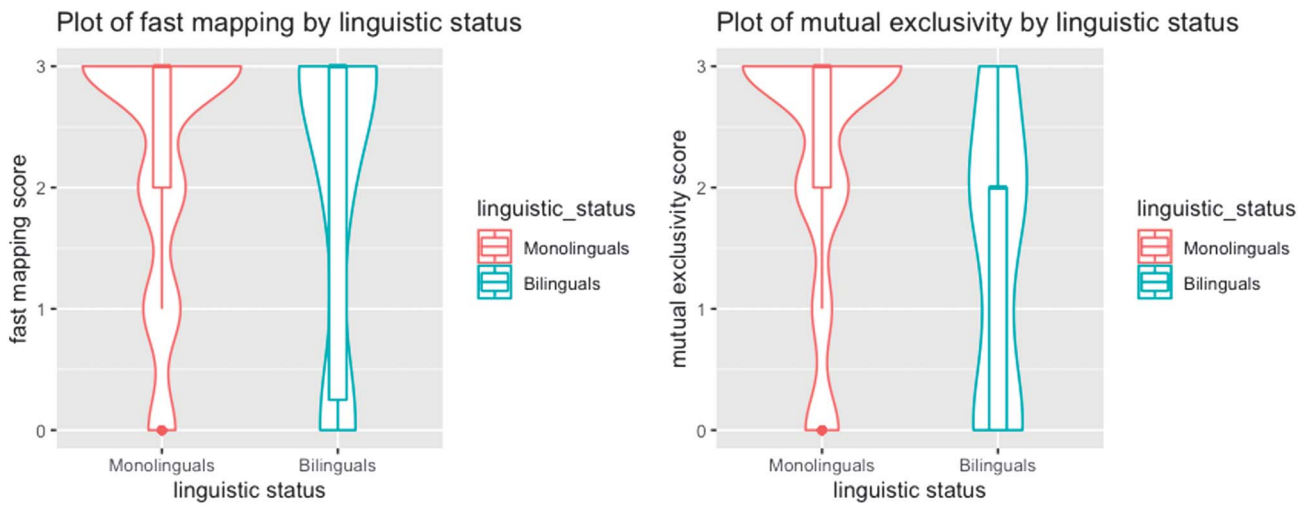
The Mutual Exclusivity part was composed of three trials (see Supplemental Material S2 for all visual stimuli and nonwords), each including a target item (a new object) and two distractors (the two known objects from the fast mapping part). At each trial, the child heard a new nonword (e.g., /pato/) in a carrier sentence such as, "Please, give me the /pato/ now. Show the /pato/," and had to select an object to give to the crocodile. A child using the mutual exclusivity strategy would associate this new word with the only new object and select it on the screen. The trials were randomized but with a fixed arrangement of the objects within each trial.

Measures of Parental Education Level and Nonverbal Reasoning

The family's educational level was assessed by asking parents to rate their level of education on a 7-point scale (1 = *no degree*, 2 = *diploma from specialized education*, 3 = *end of mandatory school, 8–9 years of schooling*, 4 = *practical apprenticeship*, 5 = *high school degree*, 6 = *par-time university degree*, 7 = *university degree*). The highest level between the mother's and father's education was used for our analyses (see Table 1).

We also tested nonverbal reasoning with the "Categories" task of the Snijders–Oomen Nonverbal Intelligence Test (2 1/2–7; Tellegen et al., 2009), presented to the child

Figure 2. Compared medians in the fast mapping and mutual exclusivity tasks for monolingual and bilingual children. The larger the plot, the more observations there are. The tips of the whiskers represent 1.5 times the interquartile range.



during the testing sessions. We used this score as an estimate of nonverbal reasoning. This task consisted of grouping pictures by categories, with the instruction "put together what goes together" and with an increasing degree of difficulty (see Table 1).

Scoring and Analysis

For the fast mapping phase, points were assigned according to the number of exposure cycles required for successful learning (1 cycle = 3 points, 2 cycles = 2 points, 3 cycles = 1 point, no learning success = 0 point). For the mutual exclusivity phase, 1 point was awarded for each trial where the child had chosen the new object. Only children who had successfully acquired the words in the previous fast mapping task were included in the analyses of the mutual exclusivity task. We analyzed our data including the fast mapping, respectively, the mutual exclusivity scores as dependent variables (outcome), and language status (mono vs. bilingual), gender, age, nonverbal reasoning, and parental education level as independent variables (predictors). Since both variables had extremely skewed distributions and, therefore, no normal distribution of the residuals was to be expected, a regression analysis for ordinal outcome variables with proportional odds was used instead of an ordinary least squares regression.[3]

[3]Thus, the intervals of the individual values are no longer necessarily considered as equidistant, which seems plausible in view of massive ceiling effects. At the same time, it is assumed that each independent variable has an identical effect at each cumulative split of the ordinal dependent variable. In such a model, we test whether changing the predictor variable by one unit is associated with increased or decreased cumulative odds of obtaining the respective higher values at the respective splits.

Results

The ordinal regression model for predicting educational level was a good fit to the data. All assumptions, that are the same with as other logistic regressions, were met. The assumption of proportional odds did not have to be rejected ($p > .05$). For fast mapping, as we can see in Figure 2, there was no difference between monolingual and bilingual children in their abilities to pair new words with new objects ($Mdn = 3$ for both groups and odds ratio [OR] = 1.96, $p = .21$, 95% confidence interval [CI] [0.68, 5.62]). We can, however, note significant effects of age ($OR = 1.09$, $p = .02$, 95% CI [1.02, 1.16]) and nonverbal reasoning ($OR = 1.18$, $p = .02$, 95% CI [1.02, 1.35]).

Overall, 112 children, 78 monolinguals (83% of them) and 34 bilinguals (75% of them), succeeded in fast mapping the two new names after three exposure cycles, but a minority of 15 (17%) monolinguals and 11 (25%) bilinguals did not, and did thus not perform the mutual exclusivity phase.

In the mutual exclusivity part, the analysis showed a significant effect of language status (Monolinguals: $Mdn = 3$; Bilinguals: $Mdn = 2$ and $OR = 4.02$, $p = .02$, 95% CI [1.21, 13.53]). The odds of observing a one unit increase in mutual exclusivity are 4.02 times higher for monolinguals than for bilinguals (see Figure 2). Specifically, 50 out of 78 (61,4%) of monolingual children systematically chose the novel object in all three trials. The answers of bilingual children were less skewed, with only 15 out of 45 (33.3%) of them choosing the novel object in all trials. We also found a significant effect of age ($OR = 1.10$, $p = .02$, 95% CI [1.02, 1.19]). Older children gave responses consistent with mutual exclusivity more often than the younger ones. Gender, parental education and nonverbal reasoning did not yield significant effects.

In further analyses, we ran ordinal regressions again including different language combinations as variables. They had no impact neither on fast mapping nor on mutual exclusivity (p values were all between $p = .07$ and $p = .90$).

Discussion

The results for both language-fair tasks are in line with our hypotheses. Even with completely new words and objects like ours, in an innovative design that reduces as much as possible the impact of previous linguistic knowledge, the findings are consistent with previous literature. We show that monolinguals and bilinguals seem to have comparable abilities to learn new words. However, similar to what Kan and Windsor (2010) mention in their meta-analysis, our results also show an influence of age and of nonverbal reasoning on fast mapping abilities. This correlation suggests the importance of cognitive aspects in the processing of information necessary to learn new words.

Despite these equivalent basic word learning abilities, we saw that monolinguals and bilinguals favor different strategies for inferring the meaning of a word when several possible referents are present. Monolingual children outperform bilingual children in using the mutual exclusivity strategy, which is consistent with prior studies (Bialystok et al., 2010; Byers-Heinlein & Werker, 2009, 2013). However, to our knowledge, this is the first time that this advantage has been clearly shown in a language-fair task that does not draw on previously known words as distractors. While the exact origin of this difference could not be established at this time, an interesting hypothesis is that the more a child is aware that an object can be linked to several different labels, the less they will use this strategy of mutual exclusivity (Byers-Heinlein & Werker, 2009). In fact, discovering those translation equivalents from a very young age may lead them to rely less on this deductive strategy. Our language-fair study is one more argument supporting the robustness of this effect, and goes against the alternative hypothesis that differences in the mutual exclusivity usage may be due to task-specific properties such as familiarity of the labels of the distractor objects. Our results then support the idea that monolingual/bilingual differences really reflect differences in cognitive functioning.

Thus, it seems that the nature of linguistic environment (i.e., monolingual or bilingual) changes the way children learn new words. In fact, a purely linguistic strategy like mutual exclusivity seems helpful for children learning only one language, who can usually rely on their intuition that each object can only be designated by a single word. On the other hand, we could see in our study that bilinguals are less systematic at using this strategy. However, we showed that children from both groups were equally capable of learning new words. Previous research (De Houwer et al., 2014; Legacy et al., 2018) also showed that monolingual and bilingual children have comparable conceptual vocabularies, suggesting that bilinguals find other effective ways to map new words and objects than the ones presented in our study.

In parallel with our results about the effect on linguistic status on the use of the mutual exclusivity strategy, we also found an effect on age on this strategy, similar to Bialystok et al. (2010) or Davidson et al. (1997). Older children use mutual exclusivity more than younger ones. However, in our study, monolingual subjects reach the ceiling relatively soon. Therefore, interaction effects between language status and age would be difficult to interpret.

Additionally, a strength of our study was our exploration of several language combinations at the same time, giving us an opportunity to see if linguistic distance would play a role on the use of mutual exclusivity. For instance, one might speculate that the high percentage of cognates in French and Italian (e.g., *porte* [*FR*] – *porta* [*IT*] [*door*]) could lead children to expect new objects to have similar names across languages and thus behave more like monolingual children in our mutual exclusivity phase. But our results showed that this was not the case. In fact, we examined whether the specific linguistic background of the children played a role in fast mapping and mutual exclusivity. But neither the type of family language nor the language of origin made an additional contribution to the variance explanation. However, a limitation here is that our sample was not balanced enough to explore all combinations; Turkish–French bilinguals were not included in the current sample.

And as a general limitation, we need to remind that, due to our setting, an important amount (about 20%) of participants were lost between the fast mapping and the mutual exclusivity phase. In fact, to stick to our goal of a language-fair mutual exclusivity task, it was mandatory for children to learn the new words in the fast mapping phase to continue with the next phase.

Finally, our results also have implications for educational and therapeutic settings. Since several studies have shown that children with language disorders have difficulties learning new words (Kan & Windsor, 2010), a language-fair task geared toward the learning process for new words such as our fast mapping task could represent an interesting dynamic assessment alternative (or addition) to traditional vocabulary batteries (Schwob & Skoruppa, submitted). Furthermore, the results of our mutual exclusivity task show that the way receptive word knowledge is assessed via picture choices, be it in fast mapping tasks involving new words or in traditional vocabulary tasks, should be carefully scrutinized for possible disadvantages for bilingual children, as they are less likely to deduce new word meanings by elimination if they already know the names of all distractor pictures. For instance, monolingual children may correctly guess the picture of for an unfamiliar target word like "stethoscope" if they know the labels for all other distractor pictures (e.g., *doctor*, *nurse*, *medicine*) by using the mutual exclusivity strategy, but

bilingual children may not use this strategy, even if they also know the labels for the other distractor pictures, and fail to guess the item.

In conclusion, we can therefore say that this study represents another step toward a better understanding of the specificities determining the linguistic development of preschoolers learning two languages at the same time. The results of our language-fair task reinforce the findings of previous studies by showing that the linguistic environment does play a qualitative role in the way children learn language, for children with a range of language proficiencies. The continuation of the study, with a larger number of participants, will allow us to refine these analyses and contribute to the scientific understanding of the underlying learning processes of bilingual children, which can serve as a basis for concrete educational and therapeutic applications. In particular, language-fair assessment tools are still scarce, despite the many bilingual children practitioners encounter in their professional lives.

Data Availability Statement

All data from our project will be available as publicly archived data sets on SwissU Base by the end of 2023. Data from this study is available now on request to the authors.

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