Effects of reduced exposure to societal language on vocabulary and morphological knowledge of bilingual children

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Abstract: Children's vocabulary and morphological knowledge both arise from exposure to their surrounding language, albeit through different learning mechanisms. Vocabulary is driven mostly by exposure to specific words, namely token exposure, whereas knowledge of morphological regularities also arises from cumulative exposure to language patterns, namely type exposure. Here we examine the impact of the reduced exposure of bilingual children to the societal language, Hebrew, on their vocabulary and morphological knowledge. The study included 148 preschool children (half bilingual) who performed a productive vocabulary task, two inflection and two derivation tasks. One of the inflectional tasks used pseudo-words in order to examine abstract morphological knowledge while neutralizing lexical knowledge. Overall, bilingual children showed lower performance than monolingual peers across both vocabulary and morphological tasks. Importantly, error analyses, tapping into participants' ability to utilize morphological knowledge in the absence of lexical representations, revealed equivalent performance of bilingual and monolingual children in inflection, and small differences in derivation. Methodologically, these results highlight the importance of de-coupling lexical and morphological knowledge, especially when studying bilingual individuals. Theoretically, the current findings suggest that the acquisition of morphological regularities, driven mostly by type exposure, is more resilient than the acquisition of lexical knowledge, driven by token exposure, in the face of reduced exposure associated with bilingualism.

Keywords: bilingual, token, type, vocabulary, morphology.

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Introduction

Bilingual children grow up being exposed to two languages. In the case of minority or heritage language speakers, the home environment usually supports the minority language, whereas children engage with the majority, or societal, language outside the home, and often in the school environment (Armon-Lotem et al., 2019; Paradis, 2023). Because bilingual children divide their time between the two languages, their exposure to the societal language is reduced in comparison to monolingual peers, who are exposed exclusively to the majority language across different social contexts. Exposure is a driving force of language acquisition in children, and thus bilingual children acquire the societal language at a slower rate than monolingual peers (Pearson et al., 1994; Uccelli & Páez, 2007). Such findings have been demonstrated for vocabulary (In English: Bialystok et al., 2010; Hoff, 2021; in Hebrew: Prior et al., 2014), morphology (In English: Kieffer & Box, 2013; Nicoladis et al., 2007, for a meta-analysis see Bratlie et al., 2022) and syntax (In Greek: Andreou & Tsimpli, 2020; in English: Chondrogianni & Marinis, 2011).

However, reduced exposure to the societal language might not impact all domains of linguistic knowledge in the same manner. Specifically, lexical knowledge, which requires repeated encounters with each individual word (token), might be more strongly affected than morphological knowledge, which requires accumulating a critical mass of encounters with linguistic regularities across different items (type exposure; Bybee, 2007). Because specific words appear less frequently in the language than do morphological structures that are shared by many words, the impact of reduced exposure is likely to be greater on the former than the latter. Further, the acquisition of such linguistic regularities is likely influenced by the morphological structure of the societal language, and the frequency and consistency of each morphological regularity.

The current study investigates the inflectional and derivational morphological knowledge in the societal language of bilingual Hebrew speaking 5-6 year-old children, in comparison with their monolingual peers. A careful understanding of the consequences of reduced exposure for vocabulary and morphology can inform theories of the interplay between item specific knowledge and knowledge of regularities (e.g., Ramirez et al., 2014; Sparks & Deacon, 2015). In addition, in light of the central role of morphological knowledge in literacy acquisition in Hebrew (Share & Bar On, 2019), identifying gaps in the morphological knowledge of young bilingual children is critical for developing effective instruction to optimally prepare them for school entry.

Usage-Based Models of Language Acquisition

Children learn language through daily exposure and social interactions, according to usage-based models (Beckner et al., 2009; Lieven et al., 2003; Tomasello, 2001). Through such exposure to language, children learn both specific linguistic units (words) and linguistic regularities (morpho-syntax; Ellis et al., 2015). Importantly, though both facets of knowledge are driven by the input that children are exposed to, different aspects of their exposure contribute to each of them (Bybee, 2007; Fejzo, 2021). Thus, word knowledge is acquired most directly through token frequency, namely the number of exposures or encounters with a specific lexical item. Morphological knowledge, on the other hand, is linked to type frequency, namely the number of encounters with different words sharing a linguistic pattern (Ravid, 2019b; see also Michaly & Prior, 2025; Shahar-Yames et al., 2018). In both cases, researchers posit that there is a critical mass, or threshold, of exposure that is necessary before the linguistic form is successfully acquired by the learner (e.g. Fejzo, 2021; Marchman & Bates, 1994). However, critical exposure to morphological regularities, at least those encountered relatively often in the language, is likely to accrue more quickly than the critical necessary exposure to individual tokens.

Token and type frequency are of course not independent of each other. With greater linguistic input, the learner can generalize more morphological patterns by linking them to specific items in their lexicon (Shahar-Yames et al., 2018). Abstract categories are gradually learned from the items children have been exposed to, based on frequency in the input (Ashkenazi et al., 2020; Bybee, 2007). Nonetheless, as stated above, reduced linguistic input, as is the case for many bilingual children, may differentially affect lexical and morphological knowledge. Here, we investigate this question in the context of Hebrew, a language with an exceptionally rich morphology.

Hebrew Morphology

Derivational Morphology

Hebrew is characterized by a productive and complex morphology. Most Hebrew words have a morphological root, which consists of three consonants and carries the main semantic meaning (Bolozky, 2007; Schwarzwald, 2002). Root morphemes are embedded in nominal or verbal pattern morphemes, which provide the lexical category of the word. The Hebrew lexicon is based mainly on the non-linear combinations of consonantal root and affixal patterns (Ravid, Ashkenazi et al., 2016). The system includes seven verb patterns and approximately 100 noun patterns. Adjectives are formed using specific nominal or verbal patterns. For example, the root *g-d-l* combines with verbal patterns: CaCaC to form the verb *gadal* 'grew up' and hiCCiC to form the verb *higdil* 'enlarge'. The same root also combines with nominal pattern: CCiCa to

form the noun *gdila* 'growth' and CiCuC to form the noun *gidul* 'growth/tumor'. Finally, the same root also combines with the nominal/adjectival pattern CaCoC to form the adjective *gadol* 'large' (Bolozky, 2007; Schwazwald, 2002). This process creates a family of distinct words, all derived from the same root (Ashkenazi et al., 2016; Ravid, Ashkenazi et al., 2016). Importantly, not all roots combine exhaustively with all patterns. For example, a combination of the root *g-d-l* with the passive verb pattern niCCaC, which would create the form *nigdal*, is not a word in the Hebrew lexicon.

Acquisition of the Hebrew derivational verb system starts as early as age two (Berman, 1985, 2016; Ravid, 2019a). Between ages 3-5 years, children occasionally combine a consonantal root into an inappropriate pattern, showing growing awareness of the verbal morphological system, but incomplete knowledge of all lexical forms (Berman, 2003). For example, children may combine the root *p-r-k* with the niCCaC pattern and say *nifrak* instead of *hitparek* 'fall to pieces' in hitCaCeC pattern. Between the ages of 5-6 years, children acquire the full verbal pattern system (Ben-Zvi & Levie, 2016; Berman, 1985). Adjective acquisition has a more protracted developmental trajectory (Ravid, Bar-On et al., 2016). Awareness of roots increases with development, and schooling plays an important role in this process. In contrast, pattern awareness emerges later, towards adolescence, and plays a major role in Hebrew word reading and spelling (Ben-Zvi & Levie, 2016; Share & Bar-On, 2018; Ravid, 2011).

In the current study, we probe children's derivational knowledge of two structures: Deriving a verb from a noun, and deriving an adjective from a verb. In the verb derivation task, children were presented with a sentence frame including a noun, and had to then identify the root morpheme and use it to derive the appropriate verb, using one of the 3 active patterns. As described above, roots do not combine exhaustively with patterns, such that for each item there was a single correct response. In the adjective derivation task, children were presented with a sentence frame including a verb, and had to then identify the root morpheme and use it to derive the appropriate resultative adjective, using one of 3 passive verbal patterns (which also denote resultative adjectives), each corresponding to an active verbal pattern. Here as well, roots do not combine exhaustively with patterns, so each item only had one correct response.

Inflectional Morphology

Inflectional morphemes indicate different grammatical properties of words such as tense, person, gender and number. The inflectional morphology of Hebrew is mostly transparent and systematic, across the nominal, verbal and adjectival systems (Bolozky, 2007; Schwarzwald, 2002), but there are still some exceptions. For example, in the nominal system pluralization suffixes differ by the grammatical gender of the word – "*im"* for masculine, and "*ot"* for feminine. However, there are also exceptions to the rule. For example, the Hebrew singular noun *kir* 'wall' is a masculine noun but it takes the plural feminine suffix *ot*: *kirot* 'walls' (Armon-Lotem & Reznick, 2022).

Modern Hebrew contains over 200 masculine nouns that take the *ot* suffix and about 50 feminine nouns that take the *im* suffix, compared with tens of thousands of nouns with gender-linked plurals (Schwartz et al., 2009). Another reason for pluralization irregularity are morpho-phonological alterations of the stem. Thus, for example, the plural form of *simla* 'dress', a feminine noun, is not *simlot* but rather *smalot* 'dresses' (which includes a stem change). Children who are unfamiliar with the specific item tend to produce regularization errors when inflecting such words (Schwartz et al., 2009). Verb inflection in Hebrew includes suffixes marking gender and number (identical with those applied in the nominal system), and systematic pattern changes marking person and tense. Here too exceptions arise from morpho-phonological alterations.

Children generally acquire regular structures before irregular structures. In addition, in Hebrew the masculine form is acquired before the feminine form (Armon-Lotem & Reznick, 2022). Irregular forms are subject to frequency effects, as their memorization depends on opportunities for learning (Schwartz et al., 2009). The acquisition of inflectional morphology is dependent on development of the content-word and function-word lexicon, and on children's developing understanding of syntactic-semantic relations. Hebrew speaking children start marking inflections toward the end of the second year of life (Berman, 1985; 2016).

In the current study, we examine two inflection processes in Hebrew – noun pluralization and verb inflection (for person, number and tense). The noun pluralization task focused mainly on irregular inflections, namely words including a gender atypical suffix, a stem change, or both, because by the age of 6 Hebrew speaking children have mastered the regular pluralization of nouns. The verb inflection task required children to change the verb's person, gender or tense in order to fit a syntactic frame. Because the task utilized a pseudo-root in Hebrew (*š-l-z*), all inflection processes were fully regular.

Effects of Reduced Exposure on Vocabulary and Morphological Knowledge

Bilingual children, because of dividing their exposure across two languages, usually have smaller vocabularies in each of their language relative to monolingual peers (Bialystok et al., 2010; Hoff, 2021). This pattern has also been documented for bilingual Hebrew speaking children (Altman et al., 2017; Armon-Lotem et al., 2011; Katzir et al., 2019; Michaly & Prior, 2025; Schwartz, 2014; Schwartz & Katzir, 2012; Shahar-Yames et al., 2018) and adolescents (Prior et al., 2014). A recent meta-analysis reports that bilingual children speaking various societal languages have lower morphological knowledge, of both inflection and derivation, than monolingual peers (Bratlie et al., 2022). However, research regarding the morphological development of bilingual Hebrew speaking children is more limited.

Monolingual Hebrew speaking children learn to use morphological structures and to make generalizations that aid in learning new words from around 2 years of age (Ben-Zvi & Levie, 2016; Berman, 2016). Morphological learning of both inflection and derivation is interwoven with lexical growth (Ravid, 2019a). A study conducted among Hebrew-speaking toddlers around the age of two found that lexical learning in Hebrew is morphologically oriented, such that children's learning of verb inflection and derivation is coupled with the development of the verb lexicon (Ashkenazi et al., 2020). Bidirectional links between vocabulary and morphological knowledge have also been documented for bilingual Hebrew speaking elementary-school aged children (Michaly & Prior, 2025; Shahar-Yames et al., 2018).

Inflectional morphology is a highly regular and frequent system that children acquire early (Kuo & Anderson, 2006). Nevertheless, in inflectional morphology tasks in English, bilingual children with diverse language backgrounds demonstrate lower performance than monolingual children (e.g. Rattansone & Demuth, 2023). However, in Hebrew, several studies show that Russian-Hebrew bilingual children (age 3 to 8) demonstrate a rapid acquisition of regular plural inflections (Reznick & Armon-Lotem, 2022; Schwartz et al., 2009; 2014).

These findings suggest that bilingual children reach the 'critical mass' of exposure to the type frequency of pluralization in Hebrew. In contrast, monolingual children are more accurate than bilingual children in applying irregular pluralization suffixes (Reznick & Armon-Lotem, 2022; Schwartz et al., 2009; 2014), which require token exposure to the specific lexical unit. In irregular cases, children cannot rely on knowledge built through frequency of type exposure to the regular pattern, because it does not apply. Thus, bilingual children who have less exposure to the societal language, find the production of irregular forms especially challenging.

Research on the derivational knowledge of bilingual Hebrew speaking children is more limited. Altman and colleagues (2017) report that Russian-Hebrew bilingual 5-6 year olds made fewer derivationally driven errors than monolingual peers in a language production task, thus demonstrating weaker derivational knowledge in Hebrew. Michaly and Prior (2025) investigated Hebrew speaking monolingual children and Russian-Hebrew bilingual children in 2nd and 4th grade and found that the two groups demonstrated equal derivational knowledge in comprehension tasks, but here as well bilingual children had weaker derivational knowledge in language production tasks. Finally, a study comparing monolingual and bilingual Hebrew speaking 5th graders (Shahar-Yames et al., 2018) found that bilinguals had lower performance compared to monolinguals on morphological derivation tasks including real words, which require lexical knowledge. However, bilinguals and monolinguals performed equally well in tasks with pseudo-words, which require abstract morphological

knowledge that does not depend on lexical knowledge. Importantly, in all these studies bilingual children consistently had smaller Hebrew vocabularies than monolingual children.

The Current Study

Here we investigate the Hebrew lexical and morphological knowledge of bilingual preschool children, who have reduced exposure to the Hebrew language, compared to Hebrew monolingual peers. A main question of interest is to better understand the impact of reduced exposure to the societal language on acquiring linguistic knowledge driven by token frequency vs. that driven by type frequency. We address this issue in four complementary ways. First, we compare the accuracy of monolingual and bilingual children in vocabulary, inflectional morphology and derivational morphology. Second, we report correlations between vocabulary knowledge (driven by token exposure) and morphological knowledge (driven by both token and type exposure). Third, we compare the performance of monolingual and bilingual children on inflection of real irregular words (driven mostly by token exposure) vs. non-words (driven exclusively by type exposure). Finally, we report detailed error analyses, documenting to what degree monolingual and bilingual children recruit inflectional and derivational morphological knowledge (driven by type exposure) even when they are unfamiliar with a specific lexical item (driven by token exposure).

We predict that bilingual children will have lower vocabulary scores than monolingual children, as has been reported in many previous studies (e.g., Hoff, 2021; Michaly & Prior, 2025). We also predict that bilingual children will be less accurate than monolingual children in tasks including real words (one inflectional task, and two derivational tasks). Finally, we hypothesize that group differences will be reduced or eliminated in a non-word inflection task and in the error analyses. This is because bilingual children's performance on real words can be negatively impacted both by their smaller vocabulary knowledge (token) and by their smaller morphological knowledge (type), but performance on non-words only depends on morphological knowledge, which we argue should show smaller group differences. These last two predictions are based on previous findings in Hebrew (Shahar-Yames et al., 2018) and in other languages (Bratlie et al., 2022).

Method

The study described in this work is part of the Safra Longitudinal Study, funded by the Edmond J. Safra Brain Research Center for the Study of Learning Disabilities. As part of the longitudinal study, each child was tested individually on a large battery of linguistic, numeric and cognitive tasks. In the current manuscript we only analyze the tasks assessing lexical and morphological knowledge.

Participants

The longitudinal study received Ethics approval by the Chief Scientist of the Israeli Ministry of Education and by the IRB at the University of Haifa. Letters describing the study were distributed to parents in 122 kindergarten classes in the north of Israel. Data were then collected from children whose parents gave informed consent for their participation in the study, and who willingly cooperated with the research assistants. The longitudinal sample included 1,157 Hebrew-speaking children.

The initial sample for the current study included all children identified as bilingual among the participants of the longitudinal study (n=148), and a matched number of monolingual children. Bilingual children were identified based on parent reports that a language different than Hebrew was used in the home. Monolingual children were selected such that for each bilingual child, a monolingual child of the same gender was selected from the same kindergarten class. If such a match was not available, a chid of the opposite gender was selected. The rationale of this procedure was to create two groups that are closely matched on their language exposure in the educational setting (the same kindergarten teachers) and on socio-economic status (residing in the same neighbourhoods, and as validated by measures of parental education, see below). At the time of testing, all children attended kindergarten schools where the language of instruction was Hebrew.

More detailed language background questionnaires (see below) were distributed to the parents of all bilingual children at the end of kindergarten, so that we could report detailed sample characteristics (as recommend e.g. by DeBruin, 2019; Prior & van Hell, 2021). However, only ~50% of the parents (n=74; 40 males) completed these. We therefore decided to reduce the sample only to those children for whom we had detailed information about their language environment and retained a matched number of monolingual children (n=74; 32 males) according to the same procedure described above. All the results and analyses reported in this paper are based only on this reduced sample, with 74 children per group. Based on a G*Power calculation, this reduced sample size still allows us to detect a medium effect size (0.6, which has frequently been reported in previous research) with a power of .97. However, we also analyzed the full sample, with 148 children per group, and found the same pattern of results, with a few slight differences. The performance of the wider sample is presented in Appendix B.

Most of the bilingual children in the sample spoke Russian as a home language (n=50). Other home languages include Amharic (n=8), English (n=6), Arabic (n=2), and one speaker each of Hungarian, Italian, French, Georgian, German, Japanese and Portuguese. Participant characteristics are presented in Table 1. The groups were well matched on important background variables, including age, average family income,

parental education, parental reports of children's attentional profile, and home literacy indices.

Table 1: ***Participant characteristics***

	Monolinguals		Bilinguals	
	N	*M* (*SD*)	*N*	*M* (*SD*)
Age (years)	59	6.13 (0.50)	66	6.27 (0.51)
Paternal education (scale 1-6)	52	3.35 (1.24)	60	3.77 (1.14)
Maternal education (scale 1-6)	60	3.67 (1.03)	66	3.71 (1.17)
Number of Siblings	69	2.67 (0.97)	74	2.43 (0.92)
Average family income (scale 1-5)	70	3.31 (0.65)	72	3.17 (0.76)
Attention average (scale 1-2)	73	1.77 (0.24)	74	1.79 (0.20)
Number of adult books at home (scale 1-5)	71	.267 (1.50)	73	3.22 (2.59)
Number of children's books at home (scale 1-5)	70	3.47 (1.08)	75	3.38 (0.91)
Frequency of reading stories at home (scale 1-5)	73	3.73 (1.01)	75	3.95 (0.89)

For all variables, group comparisons $p > .1$. See Appendix A for information on scales. Note that not all background information was available for all children.

Measures

Parent Questionnaires

Demographic questionnaire: included questions about family education, income and home environment (see information in Table 1, and Appendix A).

Language background questionnaire: A questionnaire completed by parents of bilingual children. It includes questions about children's exposure to their two languages, children's and parents' language proficiency, and patterns of family communication (see Table 2).

Non-Verbal Working Memory – Corsi Blocks

Working memory was assessed using a non-verbal task in which participants had to remember a sequence of spatial locations in two different conditions. In the forward condition, children were asked to reproduce a sequence of locations in the same order that it was presented to them, and in the backward condition they were asked to reproduce the sequence in the opposite order. Each condition included 6 blocks, and the length of the sequence increased by one for each consecutive block. Each block (sequence length) included 2 items, for a total of 12 items. The reliability (Cronbach's alpha) of the task in the longitudinal sample was .81, and in the current sample was .77.

Table 2: ***Language characteristics of bilingual families (N=74)***

	M (*SD*)
Mother Hebrew proficiency	3.90 (1.4)
Mother other-language proficiency	3.79 (1.7)
Father Hebrew proficiency	4.06 (1.3)
Father other-language proficiency	3.79 (1.7)
Child Hebrew proficiency	3.99 (0.8)
Child other-language proficiency	3.18 (1.5)
Child percent of exposure to Hebrew	52% (20)
Child age of exposure to Hebrew (years)	2.70 (2.1)

Parental language proficiency is based on self-rating across talking, reading and writing in each language, on a scale of 0 (non-existent) – 5 (excellent). Child language proficiency is based on parental ratings averaged across talking and understanding, on a scale of 0-5, as above.

Language Tasks

The current data were collected as part of a large-scale longitudinal study, assessing a wide range of child abilities (including early literacy, early numeracy, memory and executive functions). Thus, of necessity, the language tasks administered had to be short, in order to fit within this wide battery. Full testing materials are available on https://osf.io/q8hfn/?view_only=eddfd5d9e7d34417a64e939a2695218b

Hebrew vocabulary knowledge was assessed using a picture naming test, consisting of 14 items, all depicting nouns (Goralnik, 1995). Children were presented with one picture at a time, and requested to state its name in Hebrew. Accuracy was coded online. The reliability (Cronbach's alpha) of the task in the longitudinal sample was .84, and in the current sample was .79. Because bilingual children spoke eleven different home languages, it was unfeasible to test their vocabulary knowledge in their home language as well.

Morphological tasks. Morphological knowledge was assessed using four tasks: two measuring inflectional morphology and two measuring derivational morphology. Before each task, children completed two example items, on which they received feedback. Then, the test items were read to the children without further explanation and feedback. For all morphological tasks, the experimenter documented the child's response in writing and also coded it online as being correct or incorrect. We first analyzed children's overall accuracy in each of the tasks, transformed to percent correct due to the differences in number of items across tasks. Second, for the nonword inflection task and both derivation tasks, we coded offline the types of morpho-

logical information retained in children's answers, when they did not give the expected (correct) response. This partial information coding scheme is described below, for each task.

Inflectional Morphology

Noun Pluralization (Cohen-Mimran et al., 2018b; adapted from Lavie, 2006, and Yegev, 2001). The task includes 15 items. The examiner presents a picture of a single object and says its Hebrew name. The examiner then points to the image of several objects of the same kind and asks the child to say the plural Hebrew name. The items are shown to participants in succession, followed by a spoken sentence. For example, "This is a kadur (ball). There are many _____ (kadurim, 'balls')". Of the 15 items, 1 takes a regular inflection, 8 take an irregular inflection, and 12 involve a stem change. This task was coded for overall accuracy, with 1 point given for each correct response. The reliability (Cronbach's alpha) of the task in the longitudinal sample was .77, and in the current sample was .79.

Non-Word Verb Inflection (Shalev-Laifer et al., 2013). This task consists of 10 items. The examiner reads a sentence including a verb created by combining the pseudo-root š-l-z with an existing verbal-pattern, inflected for tense, number and person. The children were requested to use the same root to complete a second sentence by using the correct inflection to create a pseudo-word that fits the morpho-syntactic context. All pseudo-words were based on the same pseudo-root (š-l-z) and the missing word included a change in tense or in person. For example, "Yesterday he šalaz, and yesterday she _____ (šalza)" – person change from masculine to feminine; or "Now you šolez, and tomorrow you _____ (tišloz)" – tense change, from present to future.

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. This score was used in the accuracy analyses and the cross-task comparisons. The reliability (Cronbach's alpha) for the accuracy coding in the longitudinal sample was .71, and in the current sample was .67.

The second score gave credit for partial morphological knowledge reflected in responses, and was used in the error analyses conducted for each task separately. The partial knowledge score relied on a detailed analysis, with one point given for each of the following: use of the same root as the stimulus sentence (root), use of the same verb pattern as the stimulus sentence (pattern), inflection in the required person (person), inflection in the required tense (tense; see Appendix C for examples). Thus, the partial score could range from 0-4 points.

Derivational Morphology

Verb Derivation (Cohen-Mimran et al., 2018c, adapted from Novogrodsky & Kreiser, 2015). This task consists of 8 items. The children were instructed to complete a sentence with a suitable verb, derived from a presented Hebrew noun. The verbs required using one of the three active patterns in Hebrew – CaCaC, CiCeC, or hiCCiC (two items also allowed for using the reciprocal pattern, hitCaCeC). For example, "What do we do with the tseva (color)? With the tseva _____ (tsov'im 'we color')".

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. This score was used in the accuracy analyses and the cross-task comparisons. The reliability (Cronbach's alpha) for the accuracy coding in the longitudinal sample was .74, and in the current sample was .76.

The second score gave credit for partial morphological knowledge reflected in responses, and was used in the error analyses conducted for each task separately. The partial knowledge score relied on a detailed analysis, with one point given for use of the same root as the stimulus sentence (root), and for use of one of the three possible verb patterns (pattern; see Appendix C for examples), thus it could range from 0-2.

Adjective Derivation (Cohen-Mimran et al., 2018a, adapted from Yegev, 2001). The task consists of 10 items. The examiner said a sentence describing a picture and the children were instructed to complete a sentence, by using the verb from the first sentence to create a suitable adjective, describing the result of the action (see Table 3). For example, "sidru ([they] organized) the books. Now the books are _____ (mesudarim, 'organized')".

Table 3: ***Hebrew resultative adjectives, mapping active verb patterns to the passive adjectival form***

Active pattern	Adjectival pattern
CaCaC – *katav* ([he] wrote)	CaCuC – *katuv* (written)
CiCeC – *sider* ([he] arranged)	meCuCaC – *mesudar* (arranged)
hiCCiC – *histir* ([he] hid)	muCCaC – *mustar* (hidden)

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. The reliability (Cronbach's alpha) for the accuracy coding in the longitudinal sample was .74, and in the current sample was .75. The second score gave credit for partial morphological knowledge reflected in responses. The partial knowledge score awarded one point for use of the same root as the stimulus sentence

(root) and one point for use of one of the possible resultative adjective patterns (pattern; see Appendix C for examples).

Procedure

Children were tested by trained research assistants in a quiet room in their school. The entire battery of the longitudinal study was administered over 3 individual sessions with each child (1-3 days apart), each lasting approximately 30 minutes. Of the measures reported here, the working memory (forward and backward), real word inflection and non-word inflection tasks were administered in the first session; Vocabulary and verb derivation tasks were administered in the second session and the adjective derivation task was administered in the third session. In each session, the tasks were administered in the order listed here, with additional tasks (not analyzed here) interleaved between them.

Parental demographic questionnaires (hard copy) were distributed to parents who gave consent to their children's participation in the study, in parallel with the children completing the in-school testing sessions. The language background questionnaires were distributed electronically to the parents of bilingual children, identified on the basis of information provided by parents in the demographic questionnaire. These were completed by the parents during the summer after children graduated from kindergarten, or during the first few months of their enrolment in first grade.

Analysis Approach

The performance of monolingual and bilingual children was compared using MANOVA, one-way and repeated measures Analyses of variance using SPSS. All dependent variables were normally distributed (Skewness values ranged from –1.05 to 0.14; Kurtosis values ranged from –0.97 to 0.37).

Results

All experimental data is available at
https://osf.io/q8hfn/?view_only=eddfd5d9e7d34417a64e939a2695218b

As a first step we compared the performance accuracy of monolingual and bilingual children across the different tasks, using a MANOVA. Monolingual children were more accurate than bilingual children in all language tasks (vocabulary and morphology), but the groups had equal performance in the non-linguistic tasks (Table 4).

Table 4: ***Mean percent correct (SD) for experimental tasks, by language group***

		Monolingual (N=74)	Bilingual (N=74)	Comparison
Working memory	Forward	42.2 (13.8)	42.1 (15.4)	$F(1, 148) = .002$, $p = .965$, $\eta_p^2 = .00$
	Backward	29.9 (20.2)	31.1 (19.3)	$F(1, 148) = .136$, $p = .713$, $\eta_p^2 = .001$
Vocabulary		74.8 (20.4)	58.5 (23.3)	$F(1, 148) = 20.5$, $p < .001$, $\eta_p^2 = .123$
Morphological Inflection	Real words, noun pluralization	72.7 (19.2)	57.0 (22.4)	$F(1, 148) = 21.1$, $p < .001$, $\eta_p^2 = .125$
	Non word, verb inflection	51.5 (23.6)	43.9 (22.6)	$F(1, 148) = 3.98$, $p = .048$, $\eta_p^2 = .026$
Morphological Derivation	Verb	59.2 (26.5)	34.8 (25.3)	$F(1, 148) = 32.9$, $p < .001$, $\eta_p^2 = .183$
	Adjective	50.1 (24.5)	42.1 (25.9)	$F(1, 148) = 15.8$, $p < .001$, $\eta_p^2 = .097$

Before analyzing performance in each morphological task independently we also wished to know to what extent the morphological tasks are correlated with each other, namely, do they tap into a single construct. Thus, in each group of speakers, we examined the correlations between performance in the four morphological tasks and in the vocabulary task by running Pearson correlation analyses. In both language groups, the three morphological tasks that included real words (Noun plural inflection, Verb Derivation, Adjective Derivation), were moderately and significantly positively correlated with each other, and with the vocabulary task. Across all three morphological tasks, children were required to recruit specific lexical knowledge with varying morphological knowledge. The final morphological task, pseudo-word verb inflection, which required only pure morphological knowledge and does not require lexical knowledge, was less strongly (though still significantly) correlated with the vocabulary measure and the three remaining morphological tasks. This pattern was especially evident among the bilingual children (Table 5).

Table 5: ***Correlations between morphological tasks by group, Monolinguals (n=74) below the diagonal and bilinguals (n=74) above the diagonal***

	1	2	3	4	5
1. Vocabulary		.652**	.358*	.692**	.637**
2. Noun Plural inflection	.609**		.304*	.680**	.616**
3. Pseudo-Word verb inflection	.419**	.526**		.325*	.348*
4. Verb derivation	.682**	.597**	.400**		.722**
5. Adjective derivation	.647**	.473**	.302*	.623**	

*p < .01, **p < .001

Comparing Performance Across Real Word and Non-Word Inflection

In order to examine the extent of the difference between the language groups in inflecting real words and non-words, we used a two-way repeated measures ANOVA, with group (Monolingual, Bilingual) as a between participant factor, and word type (Real word, Non-word) as a within participant factor (Figure 1). Monolinguals were more accurate than bilinguals across both tasks (F(1,147) = 14.8, MSE = 680.2, p < .001, η_p^2 = .091), and accuracy was higher for inflecting real words than non-words (F(1,147) = 76.5, MSE = 287.5, p < .001, η_p^2 = .342). Importantly, the interaction between group and task type was also significant, (F(1,147) = 4.29, MSE = 287.5, p = .04, η_p^2 = .03), because group differences were larger for real words than for non-words, though both differences were significant as demonstrated by post-hoc comparisons (p < .001 for real words and p = .048 for non-words).

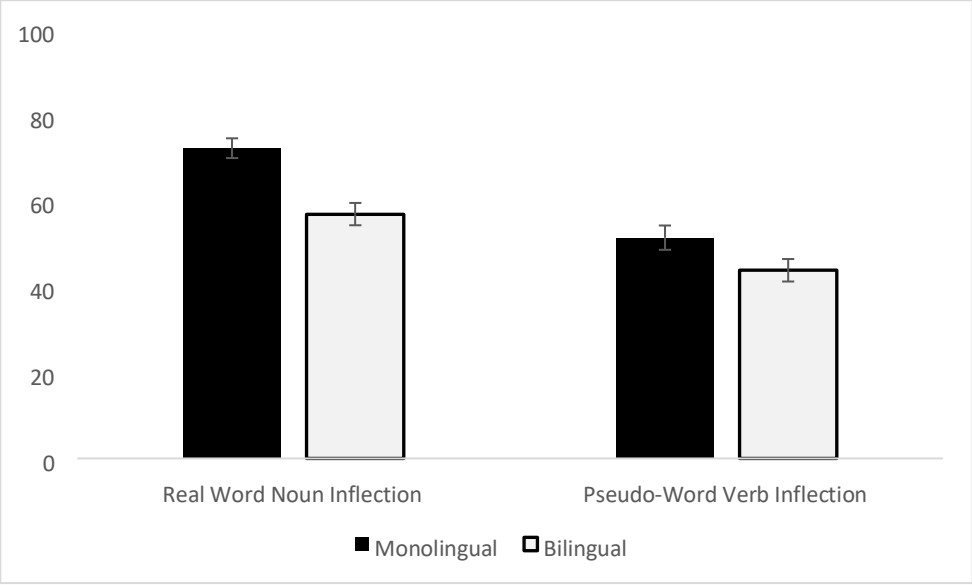

Figure1 : ***Accuracy in inflecting real nouns and pseudo-verbs, by group.***

Comparing Performance Across Verb and Adjective Derivation

To test whether there are differences between the two derivation tasks, we compared the absolute performance in the verb and adjective derivation tasks, with a two-way repeated measures ANOVA with group (Monolingual, Bilingual) as a between participant factor, and derivation type (Verb, Adjective) as a within participant factor (Figure 2). Monolinguals were more accurate than bilinguals across both tasks ($F(1,144) = 25.2$, $MSE = 1055$, $p < .001$, $\eta_p^2 = .149$), and accuracy was higher for deriving verbs than for deriving adjectives ($F(1,144) = 8.01$, $MSE = 214$, $p = .005$, $\eta_p^2 = .053$). Importantly, the interaction between group and task type was also significant, ($F(1,144) = 5.78$, $MSE = 213$, $p = .018$, $\eta_p^2 = .04$). Follow up comparisons demonstrated that whereas monolingual children had higher accuracy rates in the verb derivation than in the adjective derivation task ($t(72) = 3.4$, $p = .001$), the bilingual children showed no significant differences between the tasks ($t(74) = 0.34$, $p = .733$).

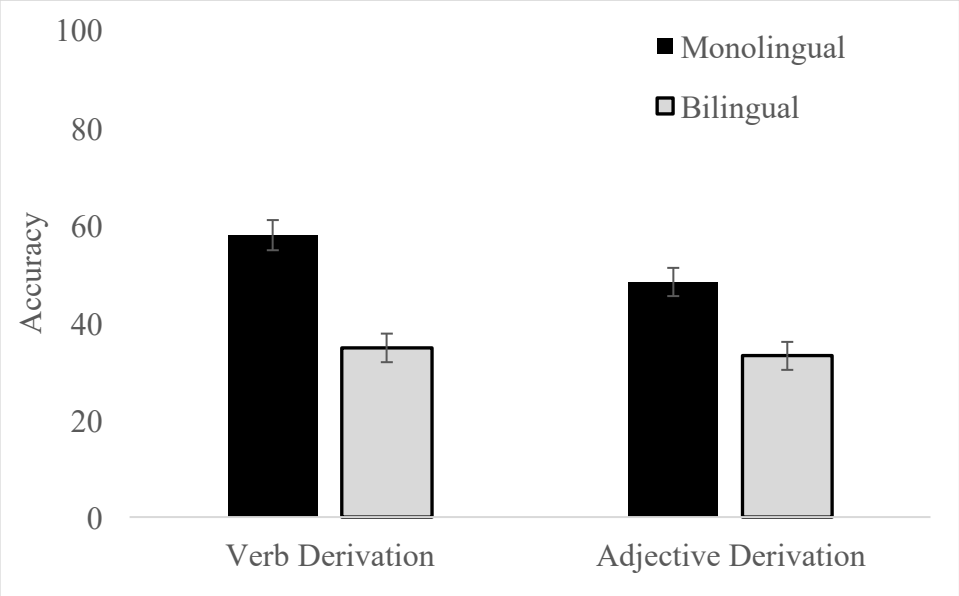

Figure 2: ***Accuracy in deriving verbs and adjectives, by group.***

Partial Knowledge Analyses

Pseudo-Word Verb Inflection

Our main question of interest here was which type of morphological knowledge children with different language backgrounds rely on when inflecting unfamiliar pseudowords. Due to the relatively lower correlations of this task with vocabulary

knowledge, the partial knowledge score is informative of children's abstract morphological knowledge. Because monolingual children were overall more accurate than bilingual children (see Table 4), we transformed the partial knowledge score to percentages. Thus, for each child we coded for the incorrectly answered items, what percent of responses preserved different types of morphological information. This allowed us to overcome the difference in basic performance and to test which type of knowledge was more accessible to children in the two groups (see examples in Appendix C1).

To this end, percentages of preserved knowledge were analyzed using a two-way repeated measures ANOVA, with group as a between-participants factor (Monolingual, Bilingual) and knowledge type as a within participant factor (Root, Pattern, Person, Tense). The main effect of group was not significant ($F < 1$), demonstrating the monolingual and bilingual children were equally able to recruit different types of morphological knowledge. The main effect of knowledge type was significant [$F(3,426) = 59.62$ $MSE = .065$, $p < .001$, $\eta_p^2 = .296$]. Participants showed the highest level of accuracy in retaining root information, ($M = 74$, $SD = 3.5$), followed by correct person inflection ($M = 50$, $SD = 0.02$) and correct tense inflection ($M = 43$, $SD = 3.0$). Children found it most difficult to preserve accurate pattern information ($M = 36.5$, $SD = 0.02$; see Figure 3). The interaction between group and error type was not significant ($F < 1$). Thus, when relying on pure morphological knowledge for inflecting pseudo-verbs, monolingual and bilingual children showed the exact same pattern of performance.

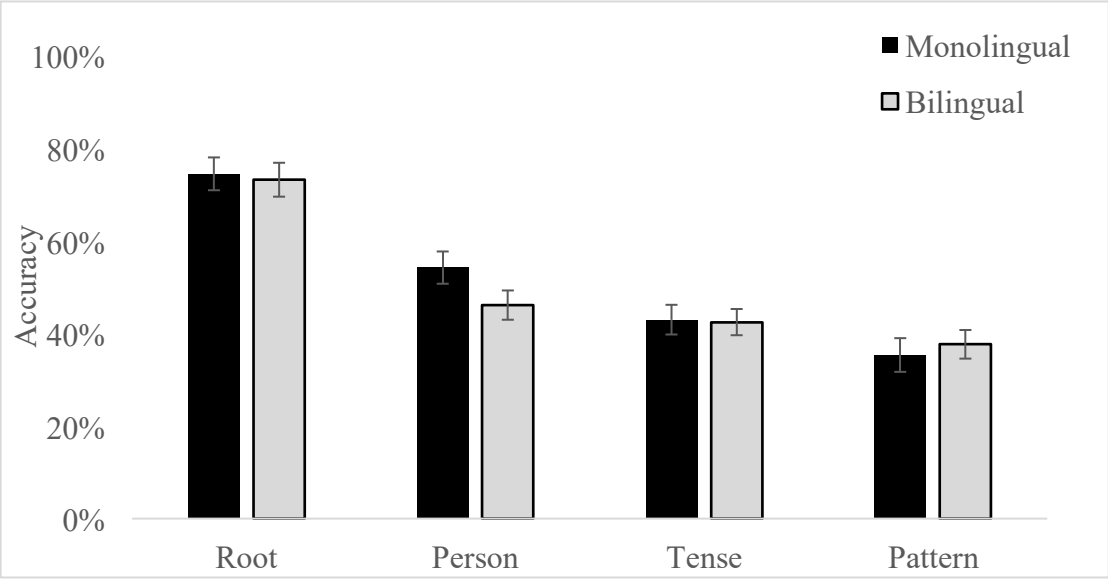

Figure 3: ***Preservation of partial knowledge in pseudo-word verb inflection, by group.***

Verb Derivation

In analyzing this task, we examined children's ability to derive real verbs from a given Hebrew noun. As reported above, monolingual children had higher scores on this task than bilingual children, when comparing simple accuracy rates (Table 4). Here, our main interest focused on the partial knowledge scores, to better understand what morphological knowledge children in both groups were able to access in attempting to produce verbs in Hebrew. We transformed the partial knowledge score to percentages, thus for each child we coded what types of morphological knowledge were preserved when he or she did not provide the fully correct expected response. This allowed us to examine whether children's responses were due to a lack of awareness of the roots, by using a word from another morphological family in an accurate pattern (e.g., said *xotxim* 'cut' in root *x-t-*x, CaCaC pattern, instead of *soxtim* 'squeeze' in root *s-x-*t, CaCaC pattern), or due to a lack of specific lexical knowledge by producing an incorrect combination of the correct root in a possible verbal pattern (e.g., said *masxitim* in root *s-x-*t, hiCCiC pattern, instead of *soxtim* 'squeeze' in root *s-x-*t, CaCaC pattern. See further examples in Appendix C2).

To this end, the partial knowledge scores were analyzed using a two-way repeated measures ANOVA, with group as a between-participants factor (Monolingual, Bilingual) and knowledge type as a within participant factor (Root, Pattern). The main effect of group was significant ($F(1,142) = 11.04$, $MSE = .073$, $p = .001$, $\eta_p^2 = .72$), because monolingual children managed to express more correct morphological information even when they made errors ($M = 45.8$) compared to bilingual children ($M = 35.2$). The main effect of knowledge type was also significant ($F(1,142) = 404.06$, $MSE = .056$, $p < .001$, $\eta_p^2 = .74$). Follow up analyses revealed that participants most easily expressed morphological knowledge in choosing an appropriate pattern ($M = 68.4$, $SD = 3.6$), but found it more difficult to preserve root information ($M = 12.6$, $SD = 2.2$; see Figure 4). Finally, the interaction between group and knowledge type was not significant ($F(1,142) = 3.042$, $MSE = .056$, $p = .083$, $\eta_p^2 = .021$).

This pattern of results shows that in most cases the children adopted a lexical strategy, that is they produced an existing verb in an appropriate pattern, which fits semantically, but does not use the required root (e.g., with the noun drum (*tof*), children responded with *menagnim* 'play an instrument' instead of *metofefim,* 'beat'). In a minority of the cases, where children retained the root in their response, they did indeed use a morphological strategy, whereby they incorporated a required root in a possible verbal-pattern (e.g., with the noun *masxeta* 'juicer' they produced the verb *masxitim* in the hiCCiC pattern, which is not a lexical item in Hebrew, instead of *soxtim* 'squeeze' in the CaCaC pattern, which does exist in the Hebrew lexicon) This pattern was common to both monolingual and bilingual children.

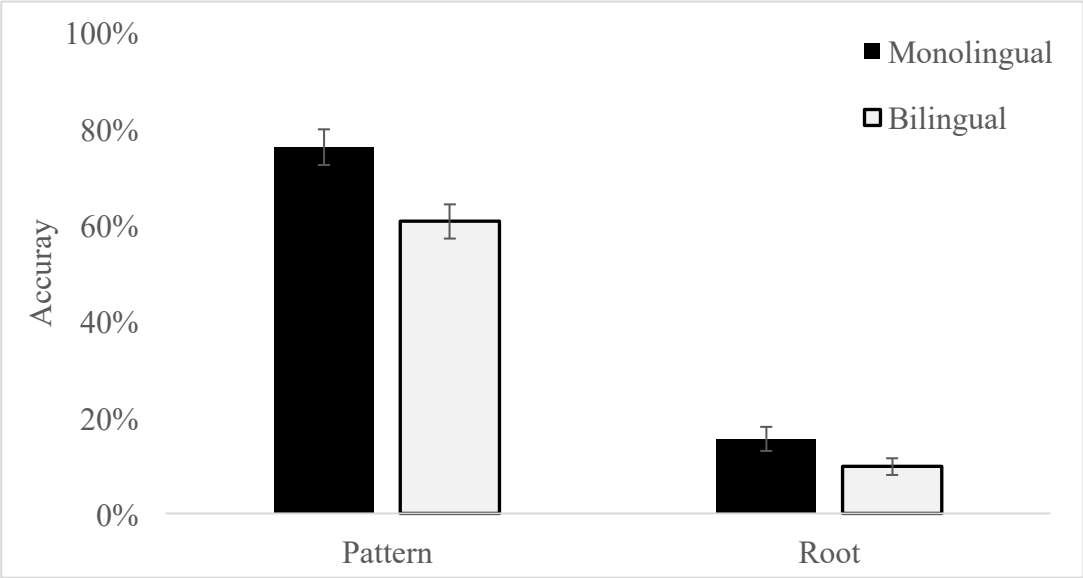

Figure 4: ***Preservation of partial knowledge in verb derivation, by group***

Adjective Derivation

In analyzing this task, we examined children's ability to morphologically derive real adjectives from given Hebrew verbs. Our main question of interest here was what types of morphological knowledge would be accessible to children in both groups when producing adjectives in Hebrew. We transformed the partial knowledge score to percentages, thus for each child we coded the percentage of errors in which knowledge of each type was preserved. This allowed us to examine whether the errors were due to a lack of awareness of the roots, as when children used a word from another morphological family (e.g., said *mušlam* 'perfect' in root *š-l-m* instead of *murkav* 'put together' in root *r-x-v* in muCCaC pattern), or due lack of awareness of specific lexical knowledge by producing an incorrect combination of the correct root in a possible verbal pattern, but not the accurate pattern (e.g., used the correct root *r-x-v* , but embedded it CaCuC pattern and said *raxuv* , which is not a lexical item in Hebrew, instead of using the muCCaC pattern to give the correct response of *murkav* , which is an existing word in Hebrew. See further examples in Appendix C3).

The data were analyzed using a two-way repeated measures ANOVA, with group as a between-participants factor (Monolingual, Bilingual) and knowledge type as a within participant factor (Root, Pattern). The main effect of group was not significant ($F(1,142) = 2.31$, $MSE = 0.12$, $p = .131$, $\eta_p^2 = .016$). The main effect of knowledge type was marginally significant ($F(1,142) = 3.55$, $MSE = 0.061$, $p = .62$, $\eta_p^2 = .024$), because children were somewhat more likely to choose a possible passive pattern (M =53.6, SD = 3.3), than to retain root information (M = 48.4, SD = 3.6). The interaction between

group and error type was significant ($F(1,142) = 3.96$, $MSE = 0.061$, $p = .048$, $\eta_p^2 = .027$). To follow up on this interaction, we conducted independent samples t-tests for each knowledge type separately. These revealed that children from both groups were similarly likely to preserve the root ($t(142) = 0.062$, $p = .95$), but monolingual children were more likely than bilingual children to produce a possible passive pattern ($t(142) = 2.49$, $p = .14$; Figure 5). As explained above, such pattern preservation mostly constitutes a lexical strategy, in which children select an alternative adjective, which uses a resultative pattern and is semantically appropriate, but which is not derived from the same root.

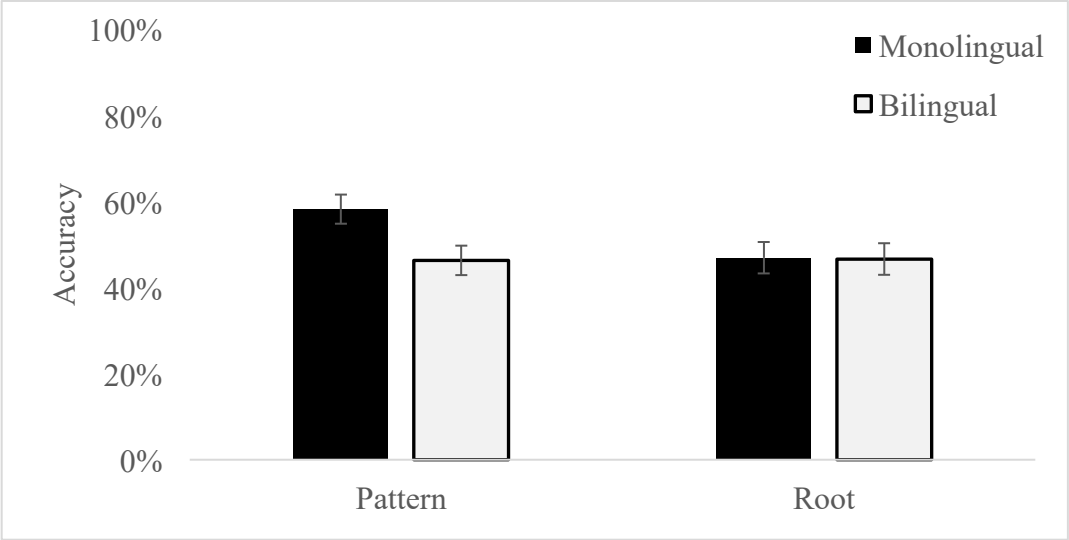

Figure 5: ***Preservation of partial knowledge in adjective derivation, by group***

Discussion

The present study examined monolingual and bilingual preschool children's knowledge of their societal language, Hebrew. As in many previous studies (e.g. Armon-Lotem et al., 2019; Hoff, 2021; Schwartz & Katzir, 2012) the bilingual children in the current sample were exposed to the societal language about 50% of the time, according to parental reports. A main goal of the study was to better understand the impact of the reduced exposure of bilingual children to the societal language on their acquisition of linguistic knowledge driven by token frequency, namely vocabulary, vs. that driven by type frequency, namely morphology. Monolinguals were significantly more accurate than bilinguals in all morphology tasks and in a vocabulary task, highlighting the critical role of reduced exposure on bilingual language development. Importantly, however, careful analyses suggest that such reduced exposure has a stronger impact on token-based knowledge than on type-based knowledge. In addition, when controlling for the contribution of lexical knowledge, bilingual children

were indistinguishable from monolinguals in their knowledge of Hebrew inflectional morphology but still showed small gaps in their knowledge of derivational morphology.

Children's language acquisition is driven by their exposure to the language around them (Bybee, 2007; Tomasello, 2001). Importantly, this exposure supports children both in learning specific words and in reaching generalizations about morpho-syntactic rules. In the current study, bilingual children had smaller Hebrew vocabularies than monolingual children, and also had lower performance in inflectional and derivational morphology tasks. These findings align with previous studies describing gaps in the vocabulary (in general Hoff, 2021; and in Hebrew, Altman et al., 2017; Shahar-Yames et al., 2018) and morphological knowledge (in general: Bratlie et al., 2022; in Hebrew: Michaly & Prior, 2025; Reznick & Armon-Lotem, 2022) of bilingual children.

The vocabulary and morphology tasks were strongly and positively correlated for both monolingual and bilingual children (with the exception of the Pseudo-word inflection task, which was only moderately correlated with the other tasks, more on this below). This finding again supports the notion that the acquisition of vocabulary and morphology are closely intertwined (Fejzo, 2021; Nicoladis et al., 2007; Ravid, 2006), and specifically that morphological knowledge is driven by both token and type exposure. Thus, as children's lexicon expands, they may find it easier to extract morphological regularities and systematic representations of inflections and derivations. At the same time, children's growing morphological knowledge can support vocabulary expansion and scaffold learning new words (Bybee, 2007).

However, in terms of being able to tease apart the contributions of type and token exposure to the acquisition of morphological regularities, and specifically to be able to examine more closely the impact of reduced exposure on this process, this close coupling is a hindrance. We addressed this issue in two ways, by including a task with pseudo-words and by looking at error patterns.

Inflection

Examining correlations between the study tasks, a weaker correlation was observed between the pseudo-verb inflection task and the rest of the tasks. Thus, pseudo-verb inflection was only moderately correlated with vocabulary, for both monolinguals and bilinguals. Similarly, pseudo-verb inflection was again only moderately correlated with the remaining morphological tasks (strongly correlated among themselves), which all involved morphological manipulation (inflection or derivation) of real vocabulary. This indicates that a task with pseudo-words more strongly relies on abstract morphological representations, and recruits lexical knowledge to a lesser degree (for similar findings see Shahar-Yames et al., 2018).

Bilinguals were less accurate than monolinguals when inflecting pseudo-verbs, but the effect was much smaller than in all other morphological tasks (see Table 4 and Figure 1), and specifically smaller than the group difference evident in the inflection of real nouns. This pattern suggests that as early as age 5, the gaps between bilingual and monolingual children in knowledge of inflection regularities in Hebrew, driven by type exposure, are smaller than the gaps evidently driven by token exposure and lexical knowledge. To wit, the group difference in the real noun inflection task, which included mostly words with irregular plural inflections, were much more pronounced. These findings align well with previous studies showing equal performance of bilingual and monolingual children on regular inflections, concurrently with group differences in irregular inflections for Hebrew (Schwartz et al., 2009, 2014; Reznick & Armon-Lotem, 2022), as well as other languages (e.g. English: Paradis et al., 2011; Rattanasone & Demuth, 2023).

This conclusion is further strengthened by analyzing the error patterns in pseudo-verb inflection, where there was no evidence for group differences. Namely, when they failed to correctly inflect the pseudo-verb, monolingual and bilingual children exhibited the exact same use of their existing morphological knowledge. Children were most likely to retain correct root information, and erred most often in not retaining the correct verbal pattern in their response. This pattern aligns with the primacy of the root over the pattern in the acquisition of Hebrew morphology (Ravid, Ashkenazi et al., 2016), though note that the facility with retaining the root might be to some degree driven by the fact that all items in this task shared the same pseudo-root. Monolingual and bilingual children were again equally likely to exhibit correct person and tense information in their responses.

Thus, before elementary school entry, bilingual Hebrew speaking children seem to have mostly reached the type exposure threshold necessary for accurate representation of the highly regular inflection system of Hebrew (Marchman & Bates, 1994). Of note, these same bilingual children have significantly lower vocabulary knowledge then their monolingual peers. These results clearly demonstrate the differential impact of reduced exposure to the societal language. In our case, children were exposed to Hebrew about 50% of the time on average, over 3.5 years. Whereas this reduction has a significant negative impact on knowledge extracted from token exposure, it did not similarly influence highly regular and consistent inflectional knowledge extracted from cumulative type exposure.

The finding that bilingual children master the regular inflection system relatively quickly has implication for instruction as well as assessment. In terms of readiness for elementary school, it seems that instructional efforts should not focus on inflectional forms, since these are mostly well established in 5-6 year-old children. How-

ever, bilingual children who demonstrate significant difficulties in correctly inflecting regular forms despite being exposed to Hebrew at least 50% of the time, might be at risk for language delay, and should thus undergo more detailed assessment.

Derivation

Monolinguals were more accurate than bilinguals in deriving verbs and adjectives in the current study. Both derivation tasks were highly correlated with vocabulary knowledge, suggesting that accurate performance relies to some extent on lexical as well as morphological knowledge. Indeed, because Hebrew roots do not combine exhaustively with the active verb patterns and passive adjective patterns tested here (Schwartzwald, 2002), producing a correct response was more likely if children were familiar with the target lexical item. Here again we see that smaller exposure to the societal language negatively impacts performance that relies on token exposure.

Analyzing the error patterns reveals a more complex picture. Examining error patterns shows us what children are capable of doing when they manifestly do not have the specific lexical knowledge required. Thus, we can tap into the abstract morphological representations that are available to them, gained exclusively through type exposure and generalization. When children from both groups were unfamiliar with the correct response in the verb derivation task, they predominantly produced an alternative verb that was semantically appropriate. Such responses used one of the possible verb patterns, but did not use the target root (Figure 4). This finding suggests that both monolingual and bilingual children have good representations of the active verb patterns, extracted based on type exposure, and aligns with the expected developmental stages of Hebrew speaking children (Ashkenazi et al., 2016; Ravid, 2019a). Notably, monolingual children produced such pattern-preserving responses significantly more often than did bilingual children.

One interpretation is that bilingual children were less successful in extracting such abstract morphological knowledge due to their reduced exposure to the language, and specifically reduced type exposure. However, we wish to argue that this observed group difference might at least partially be driven by gaps in lexical knowledge as well. Specifically, producing a verb derived from a different root can be characterized as representing a lexical response strategy, one that relies on retrieving an appropriate word from the lexicon and not necessarily on completing a morphologically driven derivation process. Because bilingual children have reduced token exposure and smaller Hebrew vocabularies, it is likely that in some cases such an alternative was not available to them.

In a minority of the cases (about 15%), children did use the target root to derive a verb using one of the possible patterns (though not the expected one), demonstrating morphologically driven processing. Bilingual children tended to do this less often than

monolingual children, though the group difference was only marginal. Due to the small percent of responses in this category, as well as the weak evidence of group difference, we can only cautiously suggest that it might indicate that bilingual children indeed have less stable representations of the verbal morphology tested here, as a result of reduced type exposure. This aligns with the findings of Altman and colleagues (2017) who also reported fewer morphologically motivated errors in bilingual than in monolingual children of the same age group tested here, and with those of Michaly and Prior (2025) showing smaller derivational knowledge in bilingual 2nd and 4th graders, relative to monolingual peers.

Error analysis of the adjective derivation task showed some similarities to the verb derivation task. When unfamiliar with the target adjective, here as well children from both groups predominantly produced a semantically appropriate adjective, derived in one of the three possible patterns, but not using the target root. As observed for verbs, monolingual children were significantly more likely to do this than bilingual children, indicating more stable morphological representations of adjective morphology, larger vocabularies, or both. In contrast, root-preserving responses were more prevalent in the adjective derivation task (~45%) than in the verb derivation task, and importantly were equally likely for monolingual and bilingual children. Children might have resorted to morphologically driven processing more often when producing adjectives than verbs because the adjective lexicon is smaller (Ben Zvi & Levie, 2016; Ravid, Bar-On et al., 2016) and they might have been less successful in retrieving an appropriate lexical alternative. Critically, bilingual and monolingual children were equally able to use the target root in an adjectival pattern, suggesting that they might not differ in their abstract morphological knowledge.

Taken together, these results clearly support the notion that bilingual children have fewer lexical resources at their disposal, due to reduced token exposure. It is less clear, however, whether bilingual children also have less-well established morphological derivational knowledge, namely have not amassed sufficient type exposure to meet the necessary threshold (Marchman & Bates, 1994). Results from the verb derivation task weakly suggest that this might be the case, but performance in the adjective derivation task demonstrates equal performance across groups.

Given the central role of derivational morphology in supporting Hebrew reading (Share & Bar-On, 2018) and writing (Ravid, 2011), we suggest that school readiness interventions with bilingual children should incorporate morphological components. Such activities could act to diminish the gaps in derivational knowledge observed here, and also provide scaffolding for expanding bilingual children's vocabulary knowledge, which is smaller than that of monolingual peers. Similarly, in light of the reciprocal relations between vocabulary and morphology, activities aimed at expanding bilingual children's exposure to Hebrew and enriching their vocabulary could also arguably benefit children's ability to extract morphological regularities.

Limitations and Future Research

The final sample analyzed here included only half of the language production data collected, due to difficulties in receiving adequate background information from the bilingual families. In addition, because the current study was part of a large-scale longitudinal study, per force the assessment tasks were rather short, though they did show good reliability. Future research could therefore study specific inflection and derivation structures in greater depth, to achieve a more nuanced picture of acquisition patterns in bilingual children.

The bilingual children studied here spoke a wide variety of home languages. Whereas this is definitely a strength of the current study in providing good generalizability of the results, it does mean that we were not able to objectively assess children's proficiency in their home language (we relied exclusively on parental reports) nor to study specific patterns of cross-language influence from different languages onto Hebrew (see e.g. Meir et al., 2017).

Conclusions

We demonstrate the impact of reduced exposure to the societal language on bilingual children's knowledge of that language, and show how it interacts with token and type based learning mechanisms. Token based performance in vocabulary and morphological tasks was lower in bilinguals than in monolinguals. However, when probing children's ability to utilize morphological knowledge in the absence of lexical representations we found equivalent performance of bilingual and monolingual children in inflection, and small differences in derivation. These results highlight the importance of research methods that can distinguish between lexical and morphological knowledge, especially when studying bilingual individuals (Shahar-Yames et al., 2018). Acquiring derivational morphology is a more protracted process than acquiring inflectional morphology in Hebrew (Ben Zvi & Levie, 2016; Berman, 2003). Therefore, whereas bilingual children were able to use their morphological knowledge in the inflection system, they had not yet reached the threshold of exposure that would allow them to do so in the derivational system, which is less systematic and regular in Hebrew. Taken together, the current findings suggest that the acquisition of morphological regularities, driven mostly by type exposure, is more resilient in the face of reduced exposure associated with bilingualism than token-based lexical learning.

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Data, Code and Materials Availability Statement

All study materials and data are available at:
https://osf.io/q8hfn/?view_only=eddfd5d9e7d34417a64e939a2695218b

Ethics Statement

The study received Ethics approval by the Chief Scientist of the Israeli Ministry of Education and by the IRB at the University of Haifa. Parents gave informed consent for their children's participation in the study, and data were collected only from children who willingly cooperated with the research assistants.

Authorship and Contributorship Statement

Anat Prior and **Gal Pedael** contributed to conception and design of the work, analysis and interpretation. **Gal Pedael** drafted the initial manuscript, and both authors were involved in revision and final approval. Both authors approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Appendix A: Scales of the Parental Demographic Questionnaire

Average family income: Average of reports for father and mother. Scale 1-5: 1-no income, 2-below average, 3-around average, 4-above average, 5-far above average.

Parental education, reported separately for mother and father. Scale 1-6: 1- high school without matriculation, 2-high school with matriculation, 3-diploma studies, 4-BA, 5-MA, 6-Ph. D or higher

Number of (adult/children) books at home Scale 1-5: 1 – 0-10, 2 – 11-20, 3 – 21-50, 4 – 50-100, 5 – over 100)

How often do you read stories to your child? Scale 1-5: 1-never, 2-once a month, 3-once a week, 4-several times a week, 5-every day

Attention score: Hebrew translation of the criteria from the DSM 5 (APA, 2013). The score reported here is the average of 18 statements about attention completed by parents about their children. “Yes” responses were coded as 1, and “no” responses were coded as 2. Thus, lower scores indicate more attentional difficulties.

Appendix B: Full Sample Data

Table B1: ***Participant characteristics, Full Sample***

	Monolinguals		Bilinguals	
	N	M (SD)	N	M (SD)
Age (years)	120	6.13 (.04)	133	7.01 (0.85)
Paternal education (scale 1-6)	111	3.50 (1.31)	111	3.68 (1.27)
Maternal education (scale 1-6)	120	3.76 (1.19)	123	3.60 (1.26)
Number of Siblings	140	2.76 (0.80)	140	2.41 (0.81)
Average family income (scale 1-5)	142	3.32 (0.65)	137	3.12 (0.85)
Attention average (scale 1-2)	148	1.77 (0.24)	140	1.77 (0.23)
Number of adult books at home (scale 1-5)	143	2.78 (1.51)	127	30.5 (2.19)
Number of children's books at home (scale 1-5)	144	3.49 (1.02)	136	3.36 (1.03)
Frequency of reading stories at home (scale 1-5)	148	3.79 (1.07)	140	3.92 (0.96)

For all variables, group comparisons p>.1. Note that not all background information was available for all children.

Table B2: ***Mean percent correct (SD) for experimental tasks by language group, Full sample***

		Monolingual (N=145)	Bilingual (N=145)	Comparison
Working memory	Forward	41.9 (13.7)	40.3 (16.5)	$F(1, 288) = .71$, $p = .402$, $\eta_p^2 = .002$
	Backward	29.8 (19.1)	29.3 (19.4)	$F(1, 288) = .04$, $p = .840$, $\eta_p^2 = .00$
Vocabulary		76.8 (17.5)	57.1 (26.2)	$F(1, 288) = 56.4$, $p < .001$, $\eta_p^2 = .164$
Morphological Inflection	Real words, noun pluralization	13.6 (17.6)	56.4 (23.3)	$F(1, 288) = 49.8$, $p < .001$, $\eta_p^2 = .148$
	Non word, verb inflection	50.9 (23.3)	42.7 (23.5)	$F(1, 288) = 8.9$, $p = .003$, $\eta_p^2 = .030$
Morphological Derivation	Verb	60.3 (24.1)	36.1 (25.8)	$F(1, 288) = 68.1$, $p < .001$, $\eta_p^2 = .191$
	Adjective	52.9 (24.9)	35.1 (26.2)	$F(1, 288) = 35.1$, $p < .001$, $\eta^2 = .109$

Appendix C: Examples of Error Coding

Non-Word Verb Inflection

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. The second score gave credit for partial morphological knowledge reflected in responses. The partial knowledge score relied on a detailed analysis, with one point given for each of the following: use of the same root as the stimulus sentence (root), use of the same verb pattern as the stimulus sentence (pattern), inflection in the required person (person), inflection in the required tense (tense; see Table C1 for examples). Responses that did not preserve the root were still given credit for the other criteria because children still performed the morphological inflection. Responses in which there was an error in the affixes of the verbal-pattern and of the tense (e.g., said *šolazet* instead of *šolezet*), did not receive credit. The criteria of person and tense were coded and received credit only if the verbal-pattern (binyan) exists in Hebrew (whether it was accurate in the present context or not).

Table C1: ***Examples of error analysis and partial scores in Non-word Verb inflection***

Error type (prompt)	Correct answer	Child response	Root	Pattern	Person	Tense
No root preservation (*šolez*)	*šolezet*	*šolexet*	0	1	1	1
Error in verbal pattern affix (*šilez*)	*šilza*	*šilaza*	1	0	0	0
Error using an existing verbal-pattern in Hebrew (*eštalez*)	*tištalez*	*išloz*	1	0	0	1
Error using a verbal-pattern that does not exist in Hebrew (*mešalezet*)	*tešalez*	*šzelt*	0	0	0	0

Verb Derivation

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. The second score gave credit for partial morphological knowledge reflected in responses. The partial knowledge score relied on a detailed analysis, with one point given for use of the same root as the stimulus sentence (root), and for use of one of the three possible resultative verb patterns (pattern; see Table C2). Responses not using the requested lexical category (e.g. using the infinitive *le-hadbik* 'to paste' instead of the inflected verb *madbikim* 'pastes') but retaining the root and an accurate verbal pattern, received points on both criteria. Similarly, responses inflected for person (e.g., using *soxetet* in the feminine singular, instead of *soxtim* in masculine plural) also received credit for both criteria. Credit for root preservation was given only if it was fully preserved, but not if it was partially represented in the children's response (e.g., said *metofim* instead of *metofefim* 'beat'). If it was not possible

to determine based on the transcription whether the response was a noun (*masrek* 'comb') or a verb (*mesarek* 'to brush'), children were given credit for the pattern. Responses including phonological mistakes (e.g., said *metopef* instead of *metofef*), were accepted as correct.

Table C2: ***Examples of error analysis and partial scores in verb derivation***

Error type (prompt)	Correct answer	Child response	Root	Pattern
No root preservation – Lexical strategy (*masxeta* 'juicer')	*soxtim*	*xotxim*	0	1
A suitable root combination in a possible pattern – Morphological strategy (*masxeta* 'juicer')	*soxtim*	*masxitim*	1	1
Using another lexical category (*devek* 'glue')	*madbikim*	*lehadbik*	1	1

Adjective Derivation

The task was scored twice: The first score is the absolute accuracy, namely 1 point for each correct answer. The second score gave credit for partial morphological knowledge reflected in responses. The partial knowledge score relied on a detailed analysis, with one point given for use of the same root as the stimulus sentence (root) and one point given for use of one of the possible resultative adjective patterns (pattern; see Table C3 for examples). Responses including an error in gender or person (e.g., using the masculine adjective *taluy* instead of feminine adjective *tluya*), received credit for both criteria. Responses including phonological mistakes (e.g., pronouncing the word 'broken' as s*habur* instead of s*havur*) were accepted as correct.

Table C3: ***Examples of error analysis and partial scores in adjective derivation***

Error type (prompt)	Correct answer	Child response	Root	Pattern
Correct root with a possible pattern, but not the accurate response (*hirkivu* 'put together')	*murkav*	*raxuv*	1	1
Root not preserved (*na'alu* 'locked')	*naul*	*sagur*	0	1
Incorrect root in a possible pattern (*tiknu* 'fix')	*metukan*	*muxan*	0	1
Person disruption only (*talu* 'hang')	*tluya*	*taluy*	1	1

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