Journal of Child Language (2025), **52,** 532–557
doi:10.1017/S0305000924000126

CAMBRIDGE UNIVERSITY PRESS

ARTICLE

Development of derivational morphological knowledge in monolingual and bilingual children: Effects of modality and lexicality

Tamar Michaly and Anat Prior

Department of Learning Disabilities and Edmond J. Safra Center for the Study of Learning Disabilities, University of Haifa
Corresponding author: Tamar Michaly; Emails: aprior@edu.haifa.ac.il; tamarmichaly@gmail.com

(Received 11 June 2023; revised 13 March 2024; accepted 01 April 2024)

Abstract

This study mapped the trajectory of developing derivational morphological knowledge in Hebrew monolingual and Russian–Hebrew bilingual children. We investigated 2nd and 4th graders, using a two-by-two structure along the dimensions of modality (comprehension, production) and type of word (real-word, pseudo-word). Performance in the morphological analogies comprehension tasks improved with grade, and monolingual and bilingual children performed equally well. A different pattern was evident in production tasks. In real-word production, monolingual children were more accurate than bilingual children, but this group difference narrowed with age. In pseudo-word production, monolingual children used more morphological elements than bilingual children, and there was also a tendency towards group differences narrowing with age. Detailed error analyses across all tasks revealed that monolingual children recruited more morphological elements than bilingual children. We present implications for assessment of morphological knowledge, and suggest that morphological intervention is a promising avenue for promoting bilingual children's success.

Keywords: morphology; derivational; morphological knowledge; bilingual children

Introduction

Globalization and migration are increasing globally, leading to a growing number of bilingual children who have a home language that differs from the societal language (Geva & Wiener, 2015). Bilingualism in children may lead to advantages in various areas of cognition (e.g., Arredondo et al., 2022; Prior et al., 2016; but see also Gunnerud et al., 2020), but in the academic domain, bilingual children tend to demonstrate smaller vocabulary knowledge in the societal language than their monolingual peers (Hoff, 2021). These disparities have been demonstrated consistently for bilingual children immersed in various societal languages including English (Bialystok et al., 2010; Proctor et al., 2005) and Hebrew (Schwartz & Katzir, 2012; Shahar-Yames et al., 2018).

In addition, some studies have shown that bilingual children are at risk for underachievement in literacy skills compared to their monolingual peers (Bratlie et al., 2022; Chiappe et al., 2002; Shahar-Yames & Prior, 2017). In the Israeli context, second-generation immigrant bilingual students achieve lower scores than monolingual peers in national verbal exams (Chachashvili-Bolotin & Kreiner, 2022; see also Bialystok et al., 2022).

Vocabulary knowledge and reading ability are strongly related to morphological knowledge (Ku & Anderson, 2003) – namely, understanding the internal structure of words. Thus, morphological knowledge might contribute to gaps in literacy between bilingual children and their monolingual peers, emphasizing the importance of studying the development of morphological knowledge among bilingual children. In the current study, we investigate in depth the morphological knowledge of bilingual Hebrew speaking children, as expressed in language comprehension and production. Theoretically, studying the acquisition of morphological knowledge in a morphologically rich language, such as Hebrew, can inform our understanding of this process and expand upon insights gained from less morphologically rich languages, such as English. Practically, a precise mapping of the morphological development of bilingual children can provide the basis for developing evidence based interventions to narrow the gaps in vocabulary and literacy between bilingual children and their monolingual peers.

Morphology

Morphological knowledge is a metalinguistic understanding that words are composed of morphemes, language units that cannot be further divided. For example, the word 'dislike' is composed of two morphemes: dis-like (Park et al., 2014). There are two types of morphological processes: inflection and derivation. Inflectional morphemes are added to a word to assign a particular grammatical property to that word (e.g., apple-s to denote plural), such as tense, person, gender, number, or possession. Derivational morphology, in contrast, is a mechanism for creating new words with new meanings in the lexicon (e.g., teach-er) (Park et al., 2014; Schwarzwald, 2002). The current study focuses only on derivational morphology.

Morphological knowledge, especially derivational morphology, makes important contributions to literacy development (Ravid & Mashraki, 2007) and supports vocabulary growth and word learning (Ku & Anderson, 2003; Tyler & Nagy, 1990). The meaning of previously unknown complex words can be deciphered through morphological analysis (Anglin et al., 1993). Learners can break complex words into constituent morphemes and synthesize the meaning of those component morphemes.

Morphological knowledge also plays a role in reading comprehension (Park et al., 2014), especially in the later stages of reading development, after acquiring basic reading skills (Carlisle, 2000). Thus, children with a greater understanding of morphology have higher reading comprehension scores when holding constant their word reading fluency (Kieffer & Lesaux, 2007). Most studies described above studied English as a societal language. In the current study, the societal language is Hebrew, which has a different morphological structure.

Hebrew morphology

Hebrew has a particularly rich morphological structure, like other Semitic languages. Most Hebrew words are comprised of two morphemes: root and pattern. The root usually

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

includes three consonants and carries the basic meaning of the word (Ravid, 1990; Schwarzwald, 2002). The pattern consists of vowels and consonants, gives specific connotations, and carries grammatical information (Berman, 2016; Levie et al., 2020; Ravid & Malenky, 2001; Ravid & Schiff, 2006). The morphology of Hebrew is non-concatenated, such that the root morpheme is intertwined with the word pattern (Ravid & Schiff, 2006). For example, the root ג.ד.ל (*g.d.l*) that carries the basic meaning 'grow' is intertwined with the pattern CCiCa to create the word גדילה (*gdila*, 'growth'). However, not all roots combine exhaustively with all patterns, and the meaning of a specific word cannot be fully predicted by analyzing the root and the pattern independently from one another (Frost et al., 2000; Levie et al., 2020).

Hebrew roots are shared across the nominal and verbal systems (Schwarzwald, 2002). In contrast, patterns differ between the two derivational systems, which allows children to acquire word-class distinctions (Menn & Ratner, 1999). The nominal system includes roughly 100 patterns (Ben-Zvi & Levie, 2016), which have inconsistent semantic properties (Frost et al., 2000). Thus, the same structural pattern may express a cluster of meanings or no specific meaning at all (Ravid, 1990). For example, the nominal pattern CaCCan mostly carries the semantic meaning of a professional (e.g., *badḳan*, 'entertainer'). However, words derived in the pattern CaCeCet fall into several different semantic "classes" – disease, device, collection, and a professional (in feminine). Finally, the pattern CeCeC does not have a semantic specialization and includes words with a wide variety of meanings (e.g., *PeTeL,* 'raspberry', *Beɨeχ,* 'knee', *SeGeL,* 'staff').

The verbal system consists of seven patterns (Ben-Zvi & Levie, 2016), denoting active, passive and reflexive meanings. Verbal patterns thus repeat often in the language, making each form very salient (Frost et al., 2000), although the frequency of different patterns varies quite substantially (Levie et al., 2020). As in the nominal system, not every root combines with every verbal pattern.

Ravid and Schiff (2006) examined morphological knowledge of nouns in monolingual Hebrew children in elementary school by testing their ability to extract and recombine roots and patterns from written Hebrew using a linguistic analogy task. The task included both real-words and pseudo-words, to investigate abstract morphological abilities not confounded by lexical knowledge. The results of both experiments indicated the same general development: both root and pattern morphemes have a role in the organization of the Hebrew lexicon as early as elementary school. Root awareness is the more central and robust of the two, and is present in children as young as 4 years old (Ravid & Malenky, 2001). Perception of the pattern is more fragile and emerges later in language development, and is not easily accessible before 5th grade (Ravid & Schiff, 2006). Ben-Zvi and Levie (2016), who examined Hebrew derivational morphology from early childhood to adolescence, reported similar results. Namely, the development of Hebrew derivational morphology is hierarchical and continues until adolescence. The verb patterns emerge first, followed by the nominal and adjectival patterns (Ben-Zvi & Levie, 2016). Notably, acquiring morphological knowledge in any language depends on the exposure of children to the language.

Usage-based models

According to usage-based models, children learn language through individual experiences with linguistic conventions used around them (Tomasello, 2001). Bilingual children are exposed less to each of their languages than monolingual children, and are thus at risk

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

of having smaller linguistic repertoires (Hoff, 2021). The question that arises is how such reduced exposure might affect different types of linguistic knowledge, such as vocabulary and morphological knowledge. Usage based approaches emphasize how the frequency of exposure to linguistic units influences the mental lexicon, and distinguish between Token and Type frequency (Fejzo, 2021). Token frequency counts the number of encounters with a specific unit, such as a word or a phrase (Bybee, 2007). Type frequency is the number of times an individual is exposed to words sharing a specific pattern (Bybee, 2007; Fejzo, 2021). Only after an individual has encountered a word or a pattern a sufficient number of times can it become productive. In other words, linguistic forms need to reach a 'critical mass' (Fejzo, 2021; Marchman & Bates, 1994).

Of relevance, the acquisition of vocabulary and of morphological patterns are driven by the different frequency mechanisms described above. Specifically, vocabulary is influenced directly by Token frequency, as a child needs to be exposed to a specific word a minimal number of times before the item becomes part of their vocabulary (Nicoladis et al., 2007). The acquisition of morphology is more complex, because it requires some degree of both Token and Type exposure, which are not independent of each other. Thus, although morphological patterns are expressed in language regularities (Bybee, 2007), and should therefore be driven by Type frequency, high Type frequency alone cannot explain children's acquisition of morphology (Nicoladis et al., 2007). A certain level of Token frequency, in addition to the threshold of Type frequency, is necessary in order to acquire a morphological pattern. For example, for a learner to become aware of the structure of a word, a certain degree of exposure to other words of the same Type (namely, Type frequency) is necessary in addition to the Token frequency which supported the initial acquisition of this word. Bybee (2007, p.15) gave an example: "If *happiness* is learned by someone who knows no related words, there is no way to infer that it has two morphemes. If *happy* is also learned, then the learner could hypothesize that *–ness* is a suffix, but only if it occurs on other adjectives would its status as a suffix become established". In addition, irregular morphological items have a lower Type frequency than the regular pattern (Bybee, 2007), and therefore their acquisition is driven more strongly by Token frequency (frequency of the specific irregular unit) than Type frequency.

As described above, bilingual children are exposed to two languages, and therefore have lower rates of exposure to the societal language than do monolingual children (Hoff, 2021). This leads to differences in rates of both Token and Type frequency in the children's input (Nicoladis et al., 2007). As mentioned, one of the main and consistent influences of reduced exposure on vocabulary acquisition in bilingual children is that they do not reach the 'critical mass' of Token exposure, resulting in smaller lexical inventories than monolingual children (Bialystok et al., 2010). However, there is a less clear understanding of how reduced exposure influences the morphological developmental trajectory.

Additional factors may also contribute to bilingual children's acquisition of morphology. Thus, it might be the case that bilingual children not only have less exposure to the societal language, but some of their input might come from non-native speakers in their environment, thus providing non-optimal learning opportunities (Hoff, 2021). However, in the current study we focus on the role of reduced exposure, by testing children in two age periods (2^{nd} and 4^{th} grade). We return to these additional mechanisms in the Discussion.

In addition, similarities between the morphological structures of children's home language and the societal language they are acquiring can facilitate learning of specific

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

morphological regularities through cross-language influences, or transfer (Pasquarella et al., 2011; Sun et al., 2023). In the current study, all children had the same linguistic background, with Russian being their home language. Russian and Hebrew have different morphological inventories: thus, in this study, a transfer between the languages is not anticipated.

The impact of exposure on morphological knowledge among bilingual children

A recent meta-analysis of 43 studies, using various morphological tasks across different languages, reported that overall bilingual children do not pick up morphological knowledge at a level comparable to their monolingual peers (Bratlie et al., 2022). The paper reports some differences between inflectional and derivation morphology, and here we focus on the latter.

Studies comparing monolingual and bilingual children's derivational morphological knowledge in English as a societal language have produced inconsistent results, with some studies finding advantages in performance for monolingual children (Kieffer & Box, 2013; Lesaux et al., 2014; Park et al., 2014; Zhang & Shulley, 2017), whereas others report no group differences (O'Toole, 2018) or even higher performance by bilingual children (Kim et al., 2015). For example, 6th grade Spanish–English bilingual children had lower performance than monolingual English speakers in a morphological derivation task (Kieffer & Box, 2013). In contrast, Kim et al. (2015) found an advantage in a morphological derivation task for Chinese–English but not Spanish–English bilingual 4th grade children over monolingual children.

There is relatively little research on the derivational knowledge of bilingual children immersed in Hebrew as a societal language (for research on inflectional morphology see Reznick & Armon-Lotem, 2022; Schwartz et al., 2009, 2014). One study found that bilingual pre-school children had less knowledge of verbal and adjectival derivation patterns than did their monolingual peers (Pedael, 2021). A study of 5th grade children again found that Russian–Hebrew bilingual children performed less well than monolingual Hebrew-speaking children in a derivational morphological task using real-words, that correlated strongly with vocabulary knowledge. However, the groups performed on par in a pure morphological task, using pseudo-words (Shahar-Yames et al., 2018), suggesting that bilingual children had accumulated the 'critical mass' necessary for abstract morphological knowledge, because it is driven by Type frequency. Taken together, these studies provide important anchor points in development, but they do not yet fully describe the trajectory and timing for acquiring Hebrew morphological knowledge among bilingual children. The current study aims to fill this gap.

Studies of morphological knowledge of bilingual children vary on many dimensions, including how morphological knowledge is measured, which might explain differences in results across studies (Bratlie et al., 2022).

How to measure morphological knowledge

Morphological knowledge is a multifaceted concept, and there are several dimensions that need to be taken into account when measuring it (Shen, 2023).

The first is the measured morphological process: inflection or derivation. Hebrew speaking children mostly complete acquiring the inflectional morphology before entering elementary school (Ben-Zvi & Levie, 2016). Monolingual and bilingual children perform

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

equally well in regular plural inflections and bilingual children only show gaps in producing irregular forms (Reznick & Armon-Lotem, 2022; Schwartz et al., 2009). However, Hebrew derivational morphology has a more protracted acquisition process, continuing through adolescence, (Ben-Zvi & Levie, 2016; Ravid & Mashraki, 2007), and we currently do not have a full description of the trajectory for acquiring Hebrew derivational morphology among bilingual Hebrew speaking children. Therefore, in the current study, we focus on the development of derivational morphology. From a usage-based approach, it would also make sense to investigate the acquisition of more and less frequent derivational patterns, with the prediction that exposure driven gaps between bilingual and monolingual children would be more evident in knowledge of patterns that are less frequently encountered. However, full empirical information about the frequency of Hebrew derivational patterns is currently only available for verb patterns (Levie et al., 2020), but not for nominal (Lavi-Mudrik, 2022) and adjectival patterns (Ravid et al., 2016). Therefore, the current study did not include measures of pattern frequency.

Another factor is modality: comprehension and production. Comprehension can be measured by choice tasks that reflect children's implicit knowledge. For example, Tyler and Nagy (1990) investigated the acquisition of English derivational morphology using multiple-choice items. In the current study, we use a multiple-choice morphological analogy task as our comprehension measure. Production tasks are more demanding because they require participants to retrieve and produce a desired form based on indirect information provided by the experimenter (Diamanti et al., 2018), a method we adopt here as well. In addition, there is general agreement that comprehension normally precedes production (Clark & Hecht, 1983). Most of the previous studies report only one of the modalities: either comprehension (Kieffer & Box, 2013; Kim et al., 2015; O'Toole, 2018; Zhang & Shulley, 2017) or production (Carlo et al., 2004; Kieffer & Lesaux, 2008; Park et al., 2014; Pedael, 2021; Proctor et al., 2005; Shahar-Yames et al., 2018), but only few studies used both types of tasks (Kieffer & Lesaux, 2012; Lesaux et al., 2014), and did not directly compare between them. Thus, in the current study, we investigate both modalities to better understand morphological development.

An additional factor is the degree to which morphological tasks depend on vocabulary (Bratlie et al., 2022). Vocabulary and morphological knowledge of school-aged children are correlated with each other (Shahar-Yames et al., 2018; Sparks & Deacon, 2015). Sparks and Deacon (2015) examined the temporal nature of the relationship, and suggested bidirectional connections between the two abilities, as morphological knowledge aids vocabulary development, and a large vocabulary supports the development of morphological knowledge. Any tasks designed to assess morphological knowledge require children to inflect or to derive real-words in the language, thus recruiting their vocabulary knowledge (e.g., Carlo et al., 2004; Shahar-Yames et al., 2018). However, assessing morphological knowledge through real-words among bilingual children raises a problem. Due to bilingual children's smaller vocabulary knowledge (e.g., Hoff, 2021), in case of underperformance in a task, it is impossible to determine whether lower performance is driven by reduced morphological knowledge or reduced vocabulary. One way to circumvent this difficulty is by using morphological tasks that require derivation of pseudo-words, as such tasks measure abstract morphological knowledge and are only weakly correlated with vocabulary knowledge (Kieffer & Box, 2013; Shahar-Yames et al., 2018). In the current study, we include both real-word and pseudo-word measures of morphological knowledge. In addition, to further examine detailed aspects of morphological knowledge, we also conduct error analyses, to determine which types of morphological knowledge are available to children.

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

The current study

In this study we seek to map the trajectory of developing morphological knowledge in bilingual Hebrew speaking children, addressing three specific goals.

First, we aim to evaluate the abstract morphological knowledge of bilingual children by incorporating both real words and pseudo-words. We hypothesize that bilingual children will demonstrate a more significant gap in real-word comprehension due to their reduced vocabulary and the inherent correlation between vocabulary and morphology.

Second, we examine the differences between in two morphological modalities separately: comprehension and production. Our hypothesis suggests that the comprehension task will be easier than the production task due to the complexity of the demands involved. Thus, we predict smaller differences between monolingual and bilingual children in comprehension than in production.

Third, we investigate the impact of education and exposure, to carefully map the developmental trends and disparities between monolingual and bilingual children. Given the concept of a critical mass of exposure necessary for acquiring morphological patterns, we hypothesize that performance of all children will improve with grade progression and ongoing exposure to the societal language, and further that group differences between monolingual and bilingual children will be attenuated, or even eliminated, in older children (especially for abstract morphological knowledge expressed in pseudo-word derivation).

To this end, we investigated two age groups: 2nd and 4th graders, using a two-by-two structure along the dimensions of modality (comprehension, production) and type of word (real-word, pseudo-word; see Table 1).

In comprehension, participants completed a written, multiple-choice analogy task (following Ravid & Schiff, 2006). In the production tasks, participants completed a sentence with a real-word (Ben-Zvi & Levie, 2016) or coined a novel pseudo-word.

Method

Participants

To identify suitable participants, letters describing the study and seeking parental approval were distributed to parents. The letter included basic questions about the home language environment, parents' ratings of their own and their children's oral and written proficiency in Hebrew and Russian, and background data and language use at home. At this stage, children who spoke languages other than Hebrew and Russian at home, children who immigrated to Israel less than 4 years before the study, or children with atypical development were excluded from the study (except for children diagnosed with ADHD, who were not excluded).

In 2nd grade, 66 parents consented to their children's participation. Six children did not want to participate, and three were absent from school on the testing days. In 4th grade,

Table 1. Study Design

	Production	Comprehension
Real–word	*Real–word Sentence Completion*	*Real–word Morphological Analogies*
Pseudo–word	*Coining New Words*	*Pseudo–word Morphological Analogies*

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Table 2. Participant characteristics

	2nd-grade		4th-grade	
	Monolingual	Bilingual	Monolingual	Bilingual
N	30	27	35	43
Age	7.99	8.02	9.75	9.68
Kaufman	22.83	24.04	26.40	27.42
Maternal Education[1]	3.70	3.48	3.06	3.60
Paternal Education[1]	3.10	3.38	2.66	3.23
Income[2]	2.63	2.70	2.8	2.74
Born in Israel	100%	85%	100%	79%
Reading habits[3]	3.03	2.81	2.83	2.86
Hebrew Vocabulary*	20.00	12.42	21.31	15.83

[1]Parent education is based on a self-reported education scale between 1-5: (1 – Less than high school, 2 - High school, 3- Professional certificate, 4 - Academic education/BA, 5- Academic education/MA or Ph.D.).
[2]Family income included a self-reported scale between 1-5: (1 – No income, 2 – Below average, 3- Average, 4 - Above average, 5 - Well above average).
[3]Reading habits are based on parental responses to the question "Do you read or have you read books to your child?" on a scale between 1-4: (1- Never, 2- Rarely, 3- Sometimes, 4- Often)
*The difference between the groups was significant $F(1,131) = 37.93$, $P < .001$, $\eta 2 = .23$)

86 parents consented, five children did not want to participate, and three were absent from school on the testing days. Therefore, the sample included 57 2nd grade students and 78 4th grade students from six different public elementary schools in central Israel. The sample was drawn from regular classes, and students were typically developing with no sensory-motor difficulties. Most participants were drawn from the same classrooms, and schools in similar neighborhoods with equivalent middle-low socio-economic status (see sample characteristics in Table 2). None of the differences in this table are statistically significant.

In 2nd-grade 30 students (60% girls) reported speaking Hebrew exclusively at home and were classified as monolingual Hebrew speakers. Twenty-seven students (67% girls) reported Russian as their native language and were initially classified as Russian–Hebrew bilingual children. Three children were diagnosed with ADHD (two bilinguals and one monolingual).

In 4th-grade 35 students (40% girls) reported speaking Hebrew exclusively at home and were classified as monolingual Hebrew speakers. Forty-three students (51% girls) reported Russian as their native language and were initially classified as Russian–Hebrew bilingual children. Three children were diagnosed with ADHD (two bilinguals and one monolingual).

As can be seen in Table 2, a majority of the bilingual children were second-generation immigrants, born in Israel. The children came from families in which both parents had emigrated from the former USSR[1]. According to parental reports, most of the children were exposed to Hebrew between the ages of 2–4 years. The ENTIRE SAMPLE had attended

[1]In 2nd grade two fathers were born in Israel, one reported fluency in all Russian language skills, and the other reported only oral fluency. In 4th grade one father was born in Israel and did not know Russian.

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Hebrew-speaking public schools from first grade. Most of the bilingual children reported speaking only Russian with their parents, or spoke both Russian and Hebrew at home. Most children watched television programs in Russian and Hebrew (or in Russian exclusively), and spoke Russian more than 50% of the time (according to the parent estimation).

Russian language proficiency was also assessed objectively using a receptive vocabulary test, Elul, (Katzir et al., 2019) translated into Russian (Yosefi, 2019). Second grade bilingual children had a mean score of 20.92 correct items, out of 35 (SD = 8.7), and 4th graders had a mean score of 24.19 correct items (SD = 5.6). The sample varied in their Russian literacy skills (see Table 3). Consistent with the educational policy in Israel, the public schools deliver literacy instruction only in Hebrew, so that any existing Russian literacy skills were taught either by family members or in afternoon classes.

Table 3. Language habits of the bilingual children

	2nd-grade	4th-grade
Age of exposure to Hebrew		
Under a year	7%	11%
Between 1–3 years	68%	33%
Between 3.5– 5.5	23%	49%
Six and above	2%	7%
The main language spoken at home		
Russian	63%	51%
Russian and Hebrew	30%	40%
Hebrew	7%	9%
Language of watching television programs		
Russian	30%	19%
Russian and Hebrew	59%	65%
Hebrew	11%	16%
Percentage of time using Russian (based on parental report)		
Under 15%	11%	9%
16%– 50%	22%	58%
Above 50%	67%	33%
Russian Literacy Abilities		
None	41%	12%
Low	15%	33%
Fairly good	11%	21%
Good	19%	26%
Very good	11%	4%
Excellent	3%	4%

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Table 4. Morphological analogy task example

	Vertical Pair I, Related by pattern CCiCa	*Vertical Pair II, Related by pattern miCCCa*
Horizontal Top Pair, Related by Root ש.ר.ף (s. ʁ. f)	sʁefɑ שרפה 'fire' (noun)	sɑiʁuf שרוף 'burnt' (adjective)
Horizontal Bottom Pair, Related by Root ג.נ.ב (g.n.v)	gnevɑ גנבה 'theft'	?

Experimental morphology measures

The study included four measures of morphological knowledge.

Morphological Analogies Task (MAT)

This was based on a task used by Ravid and Schiff (2006). The current task consisted of 21 written vowelized analogy sets, targeting morphological knowledge of words from three lexical categories: 7 nouns, 7 verbs, and 7 adjectives, from diverse patterns[2]. Each stimulus set included two pairs of morphologically related words, with the target word missing for the participants to complete. This yields a four-sided structure, the top one is a full analogy and the bottom one needs to be completed according to the top analogy (see example in Table 4)

The horizontal pairs share the same morphological root and the vertical pairs share the same morphological pattern. Thus, participants are required to complete the bottom analogy according to the pattern from the vertical (Pair II) analogy and the root from the bottom analogy. In the example, this would result in the item gɑnuv, stolen.

Participants were presented with five randomly ordered response options: a) correct response (gɑnuv גנוב; 'stolen'); b) a main root distractor – namely, a word containing the same root as the root source (bottom Pair), but not in the required pattern (hitgɑnev *התגנב*, 'Sneak away'); c) a pattern distractor – namely, a word containing the same pattern as the pattern source, but not the required root (bɑduk *בדוק*, 'Has been examined'); d) a secondary root distractor, a word containing the same root shared by members of the top pair (nisʁɑf *נשרף*, 'is burning'); e) a semantic distractor – namely, a word associated semantically or pragmatically, but not morphologically, with the correct response (lɑkɑχ *לקח*, 'took').

For each participant we calculated the percentage of correct answers and the percentage of each distractor (Main root distractor, Pattern distractor, Secondary root distractor, Semantic distractor).

Pseudo-words Morphological Analogies Task (P-MAT)

This was constructed in the same way as the MAT task (Ravid & Schiff, 2006). The task uses pseudo-roots (for example, *ק.צ.ל K.ṣ.L),* and thus allows us to separate lexical from

[2]see online supplementary materials, https://osf.io/j7nqt/?view_only=3b90da6138a14e13a8cf61198f580def

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

morphological knowledge. This task also includes 21 analogy sets, which are organized in the same manner as the MAT task described above. The patterns are identical to those used in the MAT task but are presented with pseudo-roots. The response sets and distractors are identical to those described for the MAT, with the exclusion of the semantic distractor. The task was scored the same way as the MAT test.

Real-word sentence completion

This was designed by Ben-Zvi and Levi (2016). Participants were presented with an oral sentence, and were requested to respond to a question, using a derivation of a stimulus word included in the sentence. For example, Mom **sent** (*ʃalχa*) the letter. What happened to the letter? The letter ____ (**was sent**/ *niflaχ*). In this example, the root ש.ל.ח (*ʃ.l.χ*) appears in the prompt sentence in the active form of the verb, with the pattern CaCCa, and the target response is the same root, ח.ל.ש (*ʃ.l.χ*), in the passive voice, with the pattern niCCaC. The task includes 31 sentences: 6 nouns, 10 adjectives, and 15 verbs, presented by lexical category (Shahar-Yames et al., 2018), from diverse patterns[3]. Before each lexical category, three examples were given. 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. Thus, we coded what types of morphological knowledge were preserved when participants did not provide the fully correct expected response: the root – use of the same root as the target word; or the pattern – use of a suitable pattern of the lexical category (nouns, adjectives, or verbs[4]). This partial-knowledge scoring scheme allowed us to analyze the type of morphological knowledge children can recruit when they are unfamiliar with the required lexical item. This was then summed for each participant.

Coining new words task

This is a new and experimental task designed for this study. This task examines whether children recruit morphological knowledge when they are required to coin a novel word. The task minimizes the impact of vocabulary knowledge and allows us to investigate abstract morphological knowledge directly, and whether children can rely on root and pattern knowledge as the bases for forming a new word (Berman, 2003).

Two morphological processes need to be applied when coining a novel Hebrew word from an existing word. First, root extraction – to identify the consonantal root skeleton based on which the new word is derived. Second, pattern assignment – associating a suitable pattern with this root to produce a structurally well-derived and semantically appropriate word (Berman, 2003). For example, to coin a novel word that represents a new profession of a person who erases things, we need to identify the root מ.ח.ק (*m.χ.k*) from the verb infinitive למחוק (*limχok* – 'to erase') and to find a suitable pattern for a profession, like CaCCan. Combining the root and the pattern will coin the novel word מחקן (*MaχKan*).

The task had four parts that reflect different categories (instruments, places, professions and actions). Every part included five short descriptions of different situations. Each situation contained a stimulus word, which was expected to be the basis for the root

[3]see online supplementary materials

[4]see online supplementary materials for coding examples

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

extraction and the formation of the new word. Participants were asked to coin a novel word that is suitable to the situation and which will be easily understood by others. Before each part an example was given. The situation was read by the experimenter.

An example for a situation prompting children to coin the name of an instrument: "*The teacher gave the children many sentences to copy from the blackboard. Talia said 'I wish there was a device that could write instead of the children'. If there was such a device or machine, what would you call it?*"

Task performance was scored on several dimensions. Children received one point for innovation – namely, when they indeed coined a novel word rather than using an existing Hebrew word. Using the same root of the stimulus word in the description was also awarded one point. Based on Ravid (2019) we identified suitable patterns for each semantic category included in the task (namely, instruments, places, professions, or actions[5]). Children were awarded one point for using an appropriate pattern. Finally, if children used a compounding strategy (instead of using a morphological pattern), they were also awarded one point. Thus, for each item children could receive up to 3 points, and the maximal total score was 60 points (3 points * 20 situations). Overall performance in the task was the percentage of points out of 60. We also transformed scores for each criterion (innovation, root, pattern, compound) into percentages – namely, on what percent of the trials where children produced a novel word, did they use morphological information. For example, returning to the situation described above, the stimulus word is 'to write' (לכתוב). Thus, the coined word '*MAχTeV*' gained points for the following: innovation – use of a new word; root – use of the same root as the target word in the situation description (*χ.t.v*); pattern – use of a pattern that reflects the meaning of instruments (maCCeC) for a total of 3 points. In this example, no points were awarded for compounding[6].

Background measures

Non-verbal ability

This was measured using the Kaufman Brief Intelligence Test, Second Edition (KBIT-2) (Kaufman & Kaufman, 2004). The task includes 1 training item and 46 abstract/figural problem-solving items arranged in increasing order of difficulty. Items are in multiple-choice format, with either 5 or 6 options. Participants selected and marked the best option. The task was terminated after 4 consecutive errors. The task was administered in a computerized version.

Hebrew vocabulary knowledge

This was tested using the Elul receptive vocabulary task (Katzir et al., 2019). For each word, children choose one of four possible illustrations that best match a word presented in writing and aurally. The task includes 35 items presented in increasing order of difficulty (decreasing word frequency). The reliability of the task is α=.708 (Katzir et al., 2019). The task was administered in a computerized version and was terminated after three consecutive errors.

[5]see online supplementary materials

[6]see more examples in online supplementary materials

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Russian vocabulary knowledge (for the bilingual students)

This was tested using a Russian version of the Elul receptive vocabulary task (Yosefi, 2019). For each word, children choose one of four possible illustrations that best match a word presented in writing and aurally. The task includes 35 items presented in increasing order of difficulty (decreasing word frequency). The task was administered in a computerized version and was terminated after three consecutive errors.

Procedure

The current study was part of larger project, which also investigated literacy skills. Participants were administered a battery of tests in October through May (4^{th}-grade), and March through July (2^{nd}-grade)[7] in three testing sessions, each lasting ∼30 m. Two of the sessions were administered individually and included the following tasks. Session 1 was Vocabulary (in Hebrew or in Russian), Non-verbal ability, 3 reading tasks (not analyzed here), Real-word sentence completion. Session 2 was Vocabulary (for the bilingual students in the other language), Coining new words, 4 literacy tasks (not analyzed here). The third session was administered in a group setting of 5–8 children and included the Morphological Analogies Tasks (MAT and (P-MAT), as well as a dictation task (not analyzed here). Session order was counterbalanced across participants from both groups. The order of tasks within each session was fixed. All tasks were administered during school hours in a quiet room by the first author and trained graduate students from the Department of Learning Disabilities.

Results

To meet the research goals, ANOVAs were performed for comprehension and production. For each, we took into account the developmental factor – the grade level, the group – comprising bilingual or monolingual children, and the type of the word: real words or pseudo-words.

Comprehension

We analyzed performance on morphological analogies using a three-way repeated measures ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilinguals) as between participant factors, and type of word (real-word, pseudo-word) as a within-participant factor (Table 5). The main effect of grade was significant ($F(1,127) = 16.05$, $p < .001$, $\eta 2 = .11$) with correct performance rising with grade (Table 5). However, neither the effect of word type (real-word M = 67.14, pseudo-word M = 65.85; $F<1$) nor the effect of language group (monolingual M = 69.69, bilinguals M = 63.30; $F(1,127) = 2.71$, $p = .102$) were significant. The interaction between grade and group was not significant ($F<1$).

Although both language groups reached the same level of accuracy, we further analyzed participants' errors, because as explained in the method section, the distractors in these tasks were designed to elicit specific types of morphological knowledge – root, pattern, secondary root or a semantic strategy. Partial knowledge was examined using

[7]Eight participants (2 bilinguals and 6 monolinguals) were administered the battery in October – November of the following school year

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Table 5. Mean accuracy (SD)in percentages on morphological analogies, by grade and language group

	2nd grade		4th grade	
	Monolingual	Bilingual	Monolingual	Bilingual
MAT	62.7 (20.9)	54.7 (24.3)	76.4 (22.4)	74.8 (22.1)
P-MAT	64.8 (21.8)	52.6 (25.9)	74.8 (21.5)	71.1 (25.9)

percentage scores. Thus, for each participant, we coded what percent of responses to incorrect items was of each type: root, pattern, secondary root, or semantic. Importantly, because the accuracy in these tasks was high overall, the data entering into the error analyses were rather sparse.

In the real-word morphological analogy task (MAT), a three-way ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilingual), and distractor type (main root, pattern, secondary root, semantic) shows a significant effect of distractor type ($F(3,113) = 373.74$, $p < .001$, $\eta^2 = .77$[8]). The main root distractor was the most attractive one to the children, by a wide margin. Further, there was a significant interaction between distractor type and language group ($F(3,113) = 9.39$, $p < .001$, $\eta^2 = .08$), and a marginally significant interaction between distractor type and grade ($F(3,113) = 3.10$, $p = .06$, $\eta^2 = .03$). To better understand children's preference for the different distractor types, a two-way ANOVA with grade and language group was conducted for each type separately. Monolinguals showed a stronger preference than bilinguals for the main root distractor ($F(1,115) = 11.99$, $p < .001$, $\eta^2 = .09$), and older children showed a marginally significant stronger preference than younger children ($F(1,115) = 3.27$, $p = .073$, $\eta^2 = .03$), but the interaction was not significant ($F<1$).

The percent of the time a specific child used the different distractor types always summed to 100%, therefore the analyses of the different distractor types are not independent. Thus, because bilingual children were less likely to select the main root distractors than monolingual children, they showed higher rates of selecting the other morphological distractors, both the pattern distractor ($F(1,115)=7.06$, $p= .009$, $\eta^2 = .06$); and the secondary root distractor ($F(1,115) = 5.19$, $p = .025$, $\eta^2 = .04$). Finally, the semantic distractor was used significantly more often by younger children than by older children, across both language groups ($F(1,115) = 5.43$, $p = .022$, $\eta^2 = .05$; see Figure 1A).

In the pseudo-word morphological analogies task, the results were over all very similar. A three-way ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilingual), and distractor type (main root, pattern and secondary root) shows a significant effect of distractor type ($F(2,109) = 260.27$, $p < .001$, $\eta^2 = .70$), but no significant effects of grade ($F<1$) or group ($F(1,110)=2.60$, $p = .110$, $\eta^2 = .02$). As in the real-word analogy task, the main root distractor was the most attractive one to the children, by a wide margin. In addition, there was a significant interaction between distractor type and group ($F(2,109) = 7.81$, $p = .002$, $\eta^2 = .06$), but the interaction between distractor type and grade was not significant ($F<1$). To better understand children's preference for the different distractor

[8]Where the assumption of Sphericity was violated, we report the original degrees of freedom, but the p values of statistical significance following the Greenhouse-Geisser correction. This applies to the analysis of the MAT and the PMAT performance

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

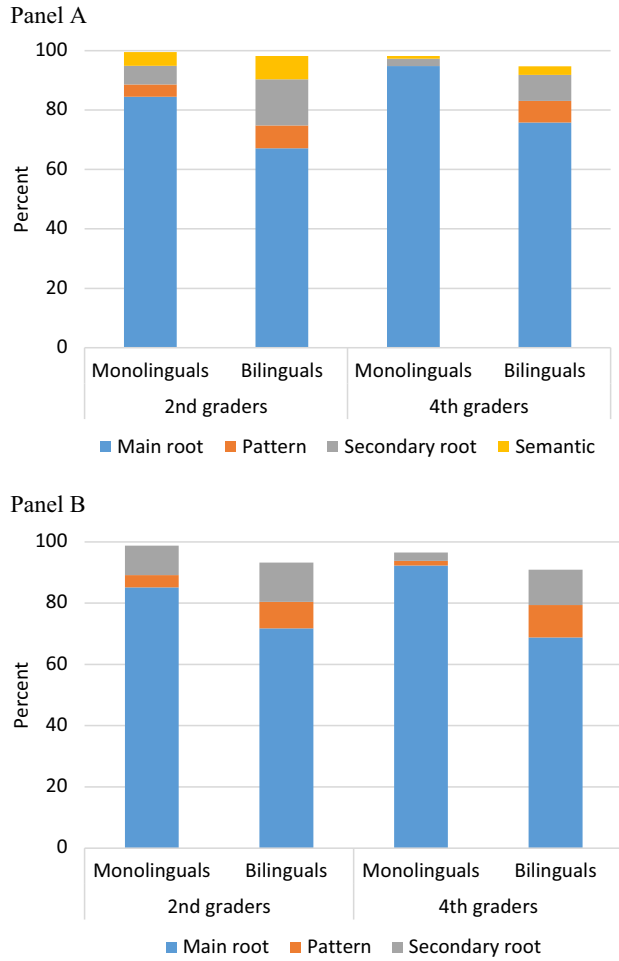

Figure 1. Error Analysis of the MAT task (panel A) and the PMAT task (panel B).

types, we once again performed a two-way ANOVA with grade and language group for each type separately. As before, monolingual children showed a stronger preference than bilingual children for the main root distractor ($F(1,110) = 10.47$, $p = .002$, $\eta^2 = .09$), but there was no difference between younger and older children ($F<1$). As in the real-word task, the analyses of the different distractor types are not wholly independent. Accordingly, bilinguals showed significantly higher rates of use for the pattern distractor ($F(1,110) = 5.31$, $p = .023$, $\eta^2 = .05$), but not for the secondary root distractor ($F(1,110) = 2.32$, $p = .132$; Figure 1.B)

Production

Different patterns were found in production tasks, in which the children were asked to produce a real-word (Real-word) or to coin a novel word (pseudo-word). In a three-way

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

repeated measures ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilingual) as between participant factors, and word type (real-word, pseudo-word) as a within participant factor, all main effects and interactions were significant. As expected, performance improved with the grade (2^{nd} graders M = 28.03, 4^{th} graders M = 44.57; $F(1,126) = 33.94$, $p < .001$, $\eta^2 = .21$). In addition, absolute accuracy in producing a real-word, a task that recruits vocabulary knowledge (M = 29.61) was lower than accuracy in coining a new word, which does not rely on lexical knowledge (M = 42.99), ($F(1,126) = 56.90$, $p < .001$, $\eta^2 = .31$). Finally, the monolinguals showed higher accuracy than the bilinguals (monolinguals M = 41.76, bilinguals M = 30.84) ($F(1,126) = 14.79$, $p < .001$, $\eta^2 = .11$). These main effects were qualified by significant two-way interactions between grade and language group ($F(1,126) = 5.24$, $p = .024$, $\eta^2 = .04$), between word type and grade ($F(1,126) = 21.02$, $p < .001$, $\eta^2 = .143$) and between word type and language group ($F(1,126) = 16.87$, $p < .001$, $\eta^2 = .12$). The three-way interaction was marginally significant as well ($F(1,126) = 3.06$, $p = .083$, $\eta2 = .0.24$).

We conducted separate two-way ANOVAs for the real-word and pseudo-word tasks, to better understand the performance patterns.

Real-word production

We conducted a two-way ANOVA with grade and language group, which showed that older children (M = 35.35) were more accurate than younger children (M= 25.05; $F(1,130) = 7.30$, $p = .008$, $\eta^2 = .05$), and monolingual children were more accurate than bilingual children (monolinguals M = 38.60, bilinguals M = 19.81; $F(1,130) = 37.48$, $p < .001.$ 008, $\eta^2 = .23$). A significant two way interaction ($F(1,130) = 10.02$, $p = .002$, $\eta^2 = .07$) and follow up comparisons found that whereas the performance of the monolingual children did not change from 2^{nd} to 4^{th} grade ($t(49) = .30$, $p = .76$) the bilingual children's performance improved significantly ($t(67) = -4.38$, $p < .001$), but they did not close the gap with monolinguals ($t(75) = 2.45$, $p = .017$; see Figure 2).

As a second step, we conducted an error analysis to investigate what types of morphological knowledge children were able to recruit when performing the task. As explained in the methods section, children could receive partial scoring for preserving morphological components in their erroneous responses. We then transformed these partial knowledge scores into percentages. Thus, for each participant, we coded whether they preserved root and/or pattern morphology when they did not provide the fully correct expected response. A three-way repeated measures ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilingual), and knowledge type (root, pattern) shows a significant main effect for grade ($F(1,130) = 22.09$, $p < .001$, $\eta^2 = .15$), since older children preserved more morphological elements. The main effect of group was marginally significant, ($F(1,130) = 3.38$, $p = .068$, $\eta^2 = .025$), and the interaction between grade and group was not significant ($F(1, 130) = 1.46$, $p = .229$ $\eta^2 = .01$). The marginal main effect of group suggests with some caution that monolingual children tended to preserve more morphological elements in their incorrect answers, which aligns with their higher performance in this task in general. Despite the non-significant interaction between group and grade, numerically the differences between monolingual and bilingual children were larger in 2^{nd} grade than in 4^{th} grade. These group and age differences were evident in the two morphological components assessed in the task – namely, the root and the pattern (see Figure 2).

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

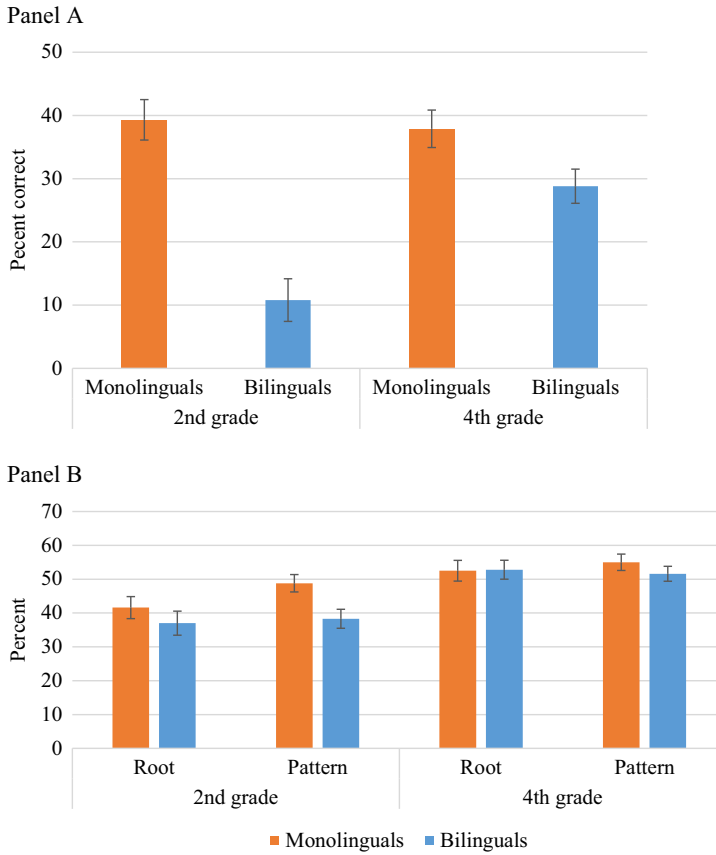

Figure 2. *Absolute performance (Panel A) and error analysis (Panel B) of the real word derivation task*

Finally, the main effect for knowledge type was also marginally significant ($F(1,130) = 393.80$, $p = .096$, $\eta^2 = .02$), suggesting that children tended to be more likely to preserve the root than to select an appropriate pattern. The interaction between grade and knowledge type was marginally significant ($F(1,130) = 2.76$, $p = .099$, $\eta^2 = .02$). Thus, older children from both language groups were able to preserve more morphological elements in their incorrect responses than were younger children.

Pseudo-word production task

Here we examined the task of coining a new word: we first analyzed children's ability to understand the task instructions and to produce a novel Hebrew word. To this end, we analyzed only the innovation criterion of this task using a two-way ANOVA with grade and language group. Older children showed a better ability to coin a new word than younger children ($F(1,127) = 40.07$, $p < .001$, $\eta^2 = .25$), but there was no difference between monolinguals and bilinguals ($F<1$) and no interaction ($F<1$). These results suggest that overall, children from both groups understood the task and were able to coin novel words in a similar manner.

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

As a second step, we conducted an analysis of the types of morphological knowledge (root, pattern, compound) that children recruited when performing the task. We transformed these partial knowledge scores into percentages – namely, on what percent of the trials in which each child produced a novel word was morphological information of each type included. A three-way mixed measures ANOVA with grade (2^{nd}, 4^{th}), language group (monolingual, bilingual) as between participant factors, and knowledge type (root, pattern, compound word) as a within participant factor shows that monolingual children produced more morphological elements than bilingual children (a main effect of group, $F(1,123) = 13.53$, $p < .001$, $\eta^2 = .10$), and older children produced more morphological elements than younger children (a significant effect of grade, $F(1,123) = 15.89$, $p < .001$, $\eta^2 = .11$). The main effect of knowledge type was also significant ($F(2,246)=822.39$, $p < .001$, $\eta^2 = .87$), because children retained the root information more often than they choose an appropriate pattern. In addition, all two way interactions were significant (grade X knowledge type, $F(2,246) = 5.49$, $p = .005$, $\eta^2 = .04$; language group X knowledge type, $F(2,246)=5.25$, $p= .006$, $\eta^2 = .04$; language group X grade, $F(1,123=3.91$, $p= .050$, $\eta^2 = .03$).

To better understand how children's morphological knowledge was expressed in their responses, a two-way ANOVA with grade and language group was conducted for each knowledge type separately. Monolingual children used the root significantly more often than did bilingual children, ($F(1,123) = 7.90$, $p = .006$, $\eta^2 = .06$), and older children used the root significantly more often than did younger children ($F(1,123) = 12.56$, $p < .001$, $\eta^2 = .09$), but the interaction between grade and language group was not significant ($F(1,123=2.62$, $p= .108$). When analyzing the use of morphological patterns, a similar picture emerged. Thus, monolingual children used the pattern significantly more often than did bilingual children, ($F(1,123) = 10.87$, $p = .001$, $\eta^2 = .08$), and older children used the pattern significantly more often than did younger children ($F(1,123) = 8.00$, $p = .005$, $\eta^2 = .06$). The interaction was marginally significant ($F(1,123=3.26$, $p= .073$, $\eta^2 = .03$), because the performance of the bilingual children seemed to improve from 2^{nd} to 4^{th} grade more than did that of monolingual children. Most children did not produce compound words, and none of the main effects were significant ($F<1$; see Figure 3).

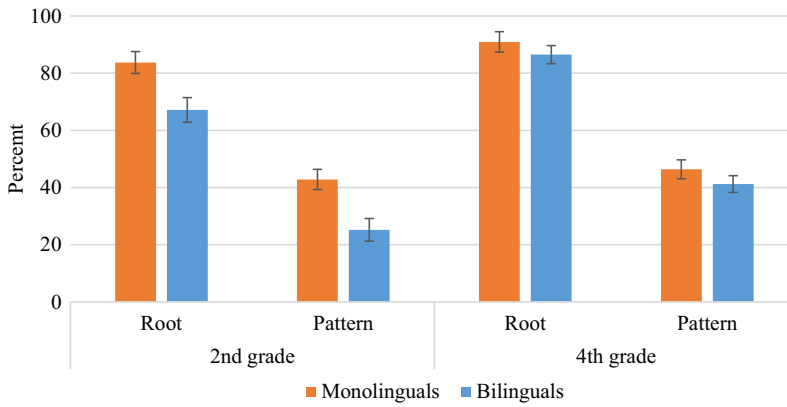

Figure 3. Morphological knowledge expressed in coining a new word

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

Discussion

The current study explored the trajectory of morphological knowledge development of 2nd and 4th grade Russian–Hebrew bilingual children compared to their monolingual peers. The derivation process was assessed across both comprehension and production with real-words and pseudo-words. In comprehension, children were asked to complete an analogy by selecting the appropriate response. Performance in the comprehension tasks rose with grade, and monolingual and bilingual children performed equally well. In real-word production, monolingual children were more accurate than bilingual children. In pseudo-word production, monolingual children used more morphological elements than bilingual children, although both groups understood the task and produced novel words at the same level. Further analysis of participants' errors revealed that monolingual children recruited more morphological elements in their responses.

Bilingual children's abstract morphological knowledge and usage-based learning

Morphological knowledge is strongly associated with lexical knowledge (Ku & Anderson, 2003; Tyler & Nagy, 1990). The first aim of the current study was to assess children's abstract morphological knowledge, and to distinguish between vocabulary and morphological knowledge (Sparks & Deacon, 2015). To this end we included both real-word and pseudo-word tasks. In real-word tasks, children may rely on their vocabulary knowledge (Bratlie et al., 2022; Shahar-Yames et al., 2018), whereas in pseudo-word tasks, the impact of vocabulary knowledge is reduced. In addition, we conducted careful error analyses, which can also shed light on the morphological knowledge children utilize when they are unfamiliar with the specific lexical item.

The patterns emerging from the comprehension and production tasks were quite different in this regard, highlighting the importance of examining both facets of performance (an issue we return to in the next section). Specifically, in the comprehension tasks, performance across words and pseudo-words was very similar and did not differ between groups. Small group differences were apparent in the error analysis, which were again consistent across real and pseudo-words, but overall monolingual and bilingual children used very similar morphological processes. In contrast, in the production tasks bilingual children were less successful than monolingual children across both word and pseudo-word tasks, and importantly used less abstract morphological knowledge.

The finding that participants from both groups were equally successful in performing real-word and pseudo-word morphological analogies (MAT and PMAT, respectively) might be explained by the task order. Children may have applied the experience they had gained with the MAT task to the PMAT task, which was always the second task. Another possibility is that the real-words in this task were of high linguistic complexity and thus essentially functioned as pseudo-words for the children. Therefore, the children did not rely on their lexical knowledge, even when presented with a real-word, and instead relied on their abstract morphological knowledge, which is driven by Type frequency (Bybee, 2007). The fact that both language groups reached the same level of accuracy suggests that despite their lower exposure to the societal language, bilingual Hebrew speaking children have nonetheless attained the 'critical mass' (Marchman & Bates, 1994) required to develop abstract morphological knowledge to the extent measured in a comprehension task. Further, the error analyses also revealed similar patterns across the MAT and the PMAT. Specifically, root distractors were overall more attractive than pattern distractors across both tasks (Ravid & Schiff, 2006), though this tendency was stronger in bilingual

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

children. Thus, the specific analogy comprehension tasks that we used here were not sensitive to performance differences putatively driven by Token and Type exposure. We were unable to identify previous studies that have directly compared monolingual and bilingual children's morphological awareness across real-words and pseudo-words in a comprehension task, so further research is needed to examine whether the pattern we report here might generalize to other languages and tasks.

In contrast, in production, bilingual children were less successful than monolingual children in both the word and the pseudo-word tasks. The lower performance of bilingual children in real-word derivation aligns with previous research (Lesaux et al., 2014; Park et al., 2014; Shahar-Yames et al., 2018; Zhang & Shulley, 2017), but as described in the introduction, it can be driven by either reduced vocabulary knowledge, reduced morphological knowledge, or both. Our finding that bilingual children were also less successful than monolingual peers in deriving pseudo-words strongly suggests that in addition to gaps in vocabulary knowledge and Token exposure, bilingual children might have not yet amassed the 'critical mass' of Type exposure necessary for productive morphological processing (Nicoladis et al., 2007). This conclusion is further supported by the partial knowledge analysis of real-word and pseudo-word derivation, which demonstrated that bilingual children used fewer morphological elements (both roots and patterns) than did monolingual children.

Therefore, it seems that gaps in overall exposure to the societal language, Hebrew, between bilingual and monolingual children are also reflected in their consolidation of abstract morphological patterns extracted from Type frequency. This suggests that the bilingual children had less exposure to root information, and that representations of derivational patterns were less robust than that of their monolingual peers. The current results regarding productive derivational morphology are in contrast to previous studies reporting that monolingual and bilingual Hebrew speaking children perform equally well in inflectional morphology (Reznick & Armon-Lotem, 2022; Schwartz et al., 2009).

Thus, incorporating real word and pseudo-word tasks, in addition to error analyses, allowed us to identify abstract morphological knowledge as one underlying source of performance differences between monolingual and bilingual children, when these were evident (i.e., in production). This finding supports the usage-based distinction between learning based on Token exposure and Type exposure (Bybee, 2007; Tomasello, 2001). Future research can extend this line of investigation by focusing on more and less frequent morphological patterns, to track how bilingual children amass the Type exposure necessary for acquiring these structures.

Comparing morphological modalities: comprehension vs. production

The second aim of the current study was to review how morphological knowledge is expressed in comprehension and production separately. As expected, the comprehension task was easier than the production tasks due to several reasons. First, production tasks require increased retrieval demands (Diamanti et al., 2018) and are thus more difficult than judgment tasks (Bratlie et al., 2022). In addition, children and language learners are able to understand the language before they are able to produce it (Clark & Hecht, 1983). The performance of bilingual children in each task type can help us understand the developmental trajectory.

In the comprehension tasks, in which participants completed analogies and chose the correct answer, bilingual and monolingual children performed equally well, and reached

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

the same level of accuracy. This finding aligns with some previous results (Kim et al., 2015; O'Toole, 2018) but not with others that report group differences on morphological awareness comprehension tasks (Kieffer & Box, 2013; Zhang & Shulley, 2017). These previous studies all examined English as the societal language, and here we present evidence from an additional societal language namely Hebrew, which has a richer morphological structure. The considerable variability in the ages of participants and specific task demands in the existing research make it difficult to offer a full explanation for variability across studies at this point. One possible explanation returns to the notion of cross-language influences, because morphological similarities across bilingual children's L1 and L2 might contribute to improved performance in morphological comprehension. However, we do not believe that this is the case in our study, because Russian and Hebrew have very different morphological inventories, and Russian does not use the same root and pattern system as Hebrew does. Alternatively, as we suggested above, the more likely explanation is that the Type exposure of bilingual children to morphological patterns in Hebrew was sufficient to establish representations that supported their performance in the comprehension task.

In contrast with the similar performance of monolingual and bilingual children in comprehension, in the more demanding production tasks, monolinguals were overall more accurate in the real-word task, and used more morphological elements than bilingual children, across both words and pseudo-words, similar to previous results (Lam & Sheng, 2016; Lesaux et al., 2014; Park et al., 2014; Shahar-Yames et al., 2018).

Thus, we found equal performance in comprehension, with remaining group differences in production. We suggest that reaching the stable morphological representations necessary for supporting production requires greater exposure than establishing the representations necessary for receptive performance (Clark & Hecht, 1983; Diamanti et al., 2018). Therefore, it is possible that the group differences we observed in production might be eliminated with continuing exposure of bilingual children to the societal language. This is supported by a study of 5th grade children from the same population, in which there were no group differences in abstract morphological knowledge production (Shahar-Yames et al., 2018). In further support of this notion, older bilingual children in the current study were more accurate than younger bilingual children in the real-word production task. Therefore, the current results reinforce the importance of assessing bilingual children's morphological knowledge across both modalities. Specifically, an assessment including only comprehension ability would not reveal existing gaps in knowledge, and might therefore deprive bilingual children of necessary support. In contrast, an assessment including only production ability would not provide information about existing knowledge that can be tapped into to support further development.

Effects of ongoing exposure and education

An important question addressed in the current study was the developmental trajectory of morphological knowledge from 2nd to 4th grade. As expected, overall performance improved with grade in all morphological tasks, aligning with previous studies showing that derivational morphology in Hebrew continues to develop throughout the school years (Ben-Zvi & Levie, 2016; Ravid, 2019). This improvement can be attributed to continuing Type exposure, which leads to more robust representations of the

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

morphological patterns (Genesee & Nicoladis, 2007) and to increasing explicit instruction of morphological principles in school.

In the current study, we set out to identify possible gaps in morphological knowledge between monolingual and bilingual children, and to address the critical question of the development trend – are gaps narrowing or widening? In comprehension, we did not find any gaps even in the younger children, because both groups performed similarly. As mentioned, this aligns with the previous discussion of comprehension preceding production.

The production tasks shed new light on the developmental trajectory. As expected, in real-word production, monolingual children were more accurate than bilingual children. This finding is not surprising because the task uses real-words, and lexical knowledge, as we confirmed, is weaker in bilingual children (Hoff, 2021; Shahar-Yames et al., 2018). However, interestingly, whereas the performance of the monolingual children did not change from 2nd to 4th grade, the bilingual children improved significantly, although they did not yet close the gap with monolinguals. Gaps in real word production were also evident in a previous study of 5th grade children (Shahar-Yames et al., 2018). Critically, in that study a partial knowledge analysis revealed no significant qualitative differences between participant groups in abstract morphological knowledge, whereas in the current study there were still differences in the error analysis between monolingual and bilingual children in 4th grade. Thus, increasing exposure with age and schooling may help bilingual children to narrow and even close the gap in abstract morphological knowledge.

In the pseudo-word production task, both monolingual and bilingual older children were better able to coin a new word and used more morphological elements than did younger children. Monolingual children used more roots and more patterns than did bilinguals. Although the interaction between age and language group was not statistically significant, the differences between monolinguals and bilinguals were numerically smaller in 4th grade than in 2nd grade. This might suggest, again, a narrowing of the gap, similar to that found in real-word production.

In summary, the morphological gaps identified among bilingual children align with the findings of the meta-analysis conducted by Bratlie et al. (2022). However, it appears that in Hebrew, there is a trend of narrowing the gaps in derivational morphology.

Implications for education

In the current study, bilingual children either performed on par with monolingual children, as in the comprehension tasks, or showed a tendency of narrowing gaps in performance with growing exposure and schooling. However, bilingual adolescents in Israel still demonstrate gaps in academic achievement even after many years of education (Chachashvili-Bolotin & Kreiner, 2022). We therefore suggest that morphological knowledge might be leveraged to support narrowing gaps in other linguistic fields.

We suggest that the design and findings of the current study might inform applied practice across both evaluation and intervention. When evaluating the morphological knowledge of bilingual children, it is important to consider task modality and to include measures of both production and comprehension, in light of the differential patterns identified in our results. In addition, especially when evaluating productive morphology, we strongly recommend including both real-words and pseudo-words. This is because any task relying on real-words involves lexical knowledge, but measures using

https://doi.org/10.1017/S0305000924000126 Published online by Cambridge University Press

pseudo-words provide a unique estimate of bilingual children's abstract morphological knowledge.

Similar considerations can also apply to interventions aimed at improving morphological knowledge of bilingual children. In terms of modality, teachers and practitioners should ensure that bilingual children practice both comprehension and production. Since production is more challenging than comprehension, direct instruction of morphological principles might be more important in supporting productive abilities. In terms of word type, there is also room to consider using both real-words and pseudo-words.

Limitations and future research

The data of this study were collected during the COVID-19 epidemic, which led to some limitations. First, the study sample is only medium sized (and smaller than planned) due to difficulties in data collection. Classes were closed from time to time, and some of the children did not attend school regularly. In addition, data were collected in the 2020-2021 school year, after children missed several months of in-school learning due to national lockdowns. Therefore, we cannot rule out the possibility that some of the patterns evident in the current data are not necessarily representative of the state of affairs under normal schooling conditions.

The current study described morphological development using a broad approach, and thus we did not specifically address the question of overlap in morphological structures between the societal language and bilingual children's L1 (as in Sun et al., 2023), nor did we compare the acquisition of less and more frequent morphological structures in Hebrew (Levie et al., 2020). Both of these are important topics for future research.

Conclusions

The current study documented the trajectory of derivational morphological knowledge development. Our results align well with previous findings of group differences in morphological knowledge between bilingual and monolingual children favoring monolingual children (Bratlie et al., 2022), with two important additional findings. First, group differences were evident only in production, and not in comprehension. Second, there was a clear trend of the gap between bilingual and monolingual children narrowing with greater age and education. Specifically, bilingual children showed an increased ability to rely on systematic morphological elements. Such abstract morphological knowledge, which derives from Type frequency, can be easier for bilingual children to acquire than word-specific knowledge, which derives from Token frequency. In a rich morphological language such as Hebrew, we believe that intervention focusing on morphological elements can reduce gaps in morphological knowledge. In light of the role of morphological knowledge in additional language and literacy skills, building morphological knowledge may be an especially promising avenue for reducing achievement gaps in general.

Acknowledgments. TM was supported by an excellence scholarship from the Graduate School at the University of Haifa. This study was partially funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) grant 398186468, awarded to AP.

Competing interest. The authors declare none

References

Anglin, J. M., **Miller, G. A.**, & **Wakefield, P. C.** (1993). Vocabulary Development: A Morphological Analysis. *Monographs of the Society for Research in Child Development*, **58**(10), i–186. https://doi.org/10.2307/1166112

Arredondo, M. M., **Aslin, R. N.**, **Zhang, M.**, & **Werker, J. F.** (2022). Attentional orienting abilities in bilinguals: Evidence from a large infant sample. *Infant Behavior and Development*, **66**, 101683. https://doi.org/10.1016/j.infbeh.2021.101683

Ben-Zvi, G., & **Levie, R.** (2016). Development of Hebrew derivational morphology from preschool to adolescence. In R. Berman (Ed.). *Acquisition and Development of Hebrew: From Infancy to Adolescence*, (pp.135–173). John Benjamins Publishing Company.

Berman, R. A. (2003). Children's lexical innovations Developmental perspectives. In J. Shimron (Ed.) *Language Processing and Acquisition in Languages of Semitic, Root-Based, Morphology*, (p.398). John Benjamins Publishing Company.

Berman, R. A. (2016). *Acquisition and Development of Hebrew: From infancy to adolescence* (Vol. **19**). John Benjamins Publishing Company.

Bialystok, E., **Hawrylewicz, K.**, **Grundy, J. G.**, & **Chung-Fat-Yim, A.** (2022). The swerve: How childhood bilingualism changed from liability to benefit. *Developmental Psychology*, **58**(8), 1429–1440.

Bialystok, E., **Luk, G.**, **Peets, K. F.**, & **Sujin, Y.** (2010). Receptive vocabulary differences in monolingual and bilingual children. *Bilingualism: Language and Cognition*, **13**(4), 525–531.

Bratlie, S. S., **Brinchmann, E. I.**, **Melby-Lervåg, M.**, & **Torkildsen, J. von K.** (2022). Morphology – A gateway to advanced language: Meta-analysis of morphological knowledge in language-minority children. *Review of Educational Research*, **92**(4), 614–650.

Bybee, J. (2007). *Frequency of Use and the Organization of Language*. Oxford, UK: Oxford University Press.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing*, **12**(3), 169–190.

Carlo, M. S., **August, D.**, **McLaughlin, B.**, **Snow, C. E.**, **Dressler, C.**, **Lippman, D. N.**, **Lively, T. J.**, & **White, C. E.** (2004). Closing the gap: Addressing the vocabulary needs of English-language learners in bilingual and mainstream classrooms. *Reading Research Quarterly*, **39**(2), 188–215.

Chachashvili-Bolotin, S., & **Kreiner, H.** (2022). Heritage-bilingualism and educational achievement among second-generation immigrants: Are all school subjects equal? *Learning and Individual Differences*, **100**, 102226. https://doi.org/10.1016/j.lindif.2022.102226

Chiappe, P., **Siegel, L. S.**, & **Wade-Woolley, L.** (2002). Linguistic diversity and the development of reading skills: A longitudinal study. *Scientific Studies of Reading*, **6**(4), 369–400.

Clark, E. V., & **Hecht, B. F.** (1983). Comprehension, production, and language acquisition. *Annual Review of Psychology*, **34**(1), 325–349.

Diamanti, V., **Benaki, A.**, **Mouzaki, A.**, **Ralli, A.**, **Antoniou, F.**, **Papaioannou, S.**, & **Protopapas, A.** (2018). Development of early morphological awareness in Greek: Epilinguistic versus metalinguistic and inflectional versus derivational awareness. *Applied Psycholinguistics*, **39**(3), 545–567.

Fejzo, A. (2021). The contribution of morphological awareness to vocabulary among L1 and L2 French-speaking 4th-graders. *Reading and Writing*, **34**, 659–679.

Frost, R., **Deutsch, A.**, **Gilboa, O.**, **Tannenbaum, M.**, & **Marslen-Wilson, W.** (2000). Morphological priming: Dissociation of phonological, semantic, and morphological factors. *Memory & Cognition*, **28** (8), 1277–1288.

Genesee, F., & **Nicoladis, E.** (2007). Bilingual first language acquisition. *Blackwell Handbook of Language Development*, 324–342.

Geva, E., & **Wiener, J.** (2015). *Psychological assessment of culturally and linguistically diverse children and adolescents*. New York, NY: Springer.

Gunnerud, H. L., **Ten Braak, D.**, **Reikerås, E. K. L.**, **Donolato, E.**, & **Melby-Lervåg, M.** (2020). Is bilingualism related to a cognitive advantage in children? A systematic review and meta-analysis. *Psychological Bulletin*, **146**(12), 1059.

Hoff, E. (2021). Why bilingual development is not easy. In J.Lockman (Ed.). *Advances in child development and behavior* (Vol. **61**, pp. 129–167). Elsevier.

Katzir, T., **Lipka, O.**, **Prior, A.**, & **Shany, M.** (2019). A multi-component approach to reading comprehension: Teacher training from mapping and intervention. Report to the Chief Scientist of the Ministry of

Education: The Edmond J. Safra Brain Research Center for the Study of Learning Disabilities. University of Haifa. (in Hebrew)

Kaufman, A. S., & **Kaufman, N. L.** (2004). *Kaufman Brief Intelligence Test* (2nd ed.). Bloomington, MN: Pearson.

Kieffer, M. J., & **Box, C. D.** (2013). Derivational morphological awareness, academic vocabulary, and reading comprehension in Spanish-speaking language minority learners and their classmates. *Learning and Individual Differences*, **24**, 168–175.

Kieffer, M. J., & **Lesaux, N. K.** (2007). Breaking down words to build meaning: Morphology, vocabulary, and reading comprehension in the urban classroom. *The Reading Teacher*, **61**(2), 134–144.

Kieffer, M. J., & **Lesaux, N. K.** (2008). The role of derivational morphology in the reading comprehension of Spanish-speaking English language learners. *Reading and Writing*, **21**, 783–804.

Kieffer, M. J., & **Lesaux, N. K.** (2012). Effects of academic language instruction on relational and syntactic aspects of morphological awareness for sixth graders from linguistically diverse backgrounds. *The Elementary School Journal*, **112**(3), 519–545.

Kim, T. J., **Kuo, L.-J.**, **Ramírez, G.**, **Wu, S.**, **Ku, Y.-M.**, **de Marin, S.**, **Ball, A.**, & **Eslami, Z.** (2015). The relationship between bilingual experience and the development of morphological and morpho-syntactic awareness: A cross-linguistic study of classroom discourse. *Language Awareness*, **24**(4), 332–354.

Ku, Y.-M., & **Anderson, R. C.** (2003). Development of morphological awareness in Chinese and English. *Reading and Writing*, **16**(5), 399–422.

Lam, B. P.-W., & **Sheng, L.** (2016). The development of morphological awareness in young bilinguals: Effects of age and L1 background. *Journal of Speech, Language, and Hearing Research*, **59**(4), 732–744.

Lavi-Mudrik, D. (2022). *Hebrew Morphological and morph-orthographic characteristics of the Hebrew nouns in texts of early reading stages*. [Master's thesis] Tel-Aviv University. (in Hebrew)

Lesaux, N. K., **Kieffer, M. J.**, **Kelley, J. G.**, & **Harris, J. R.** (2014). Effects of academic vocabulary instruction for linguistically diverse adolescents: Evidence from a randomized field trial. *American Educational Research Journal*, **51**(6), 1159–1194.

Levie, R., **Ashkenazi, O.**, **Stanzas, S. E.**, **Zwilling, R. C.**, **Raz, E.**, **Hershkovitz, L.**, & **Ravid, D.** (2020). The route to the derivational verb family in Hebrew: A psycholinguistic study of acquisition and development. *Morphology*, **30**(1), 1–60.

Marchman, V. A., & **Bates, E.** (1994). Continuity in lexical and morphological development: A test of the critical mass hypothesis. *Journal of Child Language*, **21**(2), 339–366.

Menn, L., & **Ratner, N. B.** (1999). *Methods for studying language production*. Psychology Press.

Nicoladis, E., **Palmer, A.**, & **Marentette, P.** (2007). The role of type and token frequency in using past tense morphemes correctly. *Developmental Science*, **10**(2), 237–254.

O'Toole, G. L. (2018). *Morphological representation and reading comprehension in early elementary English language learners*. University of British Columbia.

Park, J., **Wiseheart, R.**, & **Ritter, M.** (2014). The roles of the speed and accuracy of morphological processing in the reading comprehension of Spanish-speaking language minority learners. *International Journal of Applied Linguistics and English Literature*, **3**(1), 12–27.

Pasquarella, A., **Chen, X.**, **Lam, K.**, **Luo, Y. C.**, & **Ramírez, G.** (2011). Crosslanguage transfer of morphological awareness in Chinese–English bilinguals. *Journal of Research in Reading*, **34**(1), 23–42. https://doi.org/10.1111/j.1467-9817.2010.01484.x

Pedael, G. (2021). Hebrew morphological knowledge of monolingual and bilingual preschool children. *MA thesis submitted to the University of Haifa*.

Prior, A., **Goldwasser, N.**, **Ravet-Hirsh, R.**, & **Schwartz, M.** (2016). Executive functions in bilingual children. In J.W. Schwieter (Ed.). *Cognitive Control and Consequences of Multilingualism*, (pp. 323–350). John Benjamins Publishing Company.

Proctor, C. P., **Carlo, M.**, **August, D.**, & **Snow, C.** (2005). Native Spanish-speaking children reading in English: Toward a model of comprehension. *Journal of Educational Psychology*, **97**(2), 246–256.

Ravid, D. (1990). Internal structure constraints on new-word formation devices in Modern Hebrew. *Folia Linguistica*, 24(3–4), 289–348.

Ravid, D. (2019). Hebrew derivational morphology. In Berman, R.A., Dattner, E., Grossman, E., Nir, B., and Reshef, Y. 2020. *Usage-based studies in modern Hebrew : background, morpho-lexicon, and syntax*. John Benjamins Publishing Company, Philadelphia.

Ravid, D., **Bar-On, A.**, **Levie, R.**, & **Douani, O.** (2016). Hebrew adjective lexicons in developmental perspective: Subjective register and morphology. *The Mental Lexicon*, **11**(3), 401–428.

Ravid, D., & **Malenky, A.** (2001). Awareness of linear and nonlinear morphology in Hebrew: A developmental study. *First Language*, **21**(61), 25–56.

Ravid, D., & **Mashraki, Y. E.** (2007). Prosodic reading, reading comprehension and morphological skills in Hebrew-speaking fourth graders. *Journal of Research in Reading*, **30**(2), 140–156.

Ravid, D., & **Schiff, R.** (2006). Roots and patterns in Hebrew language development: Evidence from written morphological analogies. *Reading and Writing*, **19**(8), 789–818.

Reznick, J., & **Armon-Lotem, S.** (2022). Children's Command of Plural Marking on Hebrew Nouns: Evidence from Russian–Hebrew Bilingual Acquisition. In *Developing Language and Literacy: Studies in Honor of Dorit Diskin Ravid* (pp. 573–596). Springer.

Schwartz, M., & **Katzir, T.** (2012). Depth of lexical knowledge among bilingual children: The impact of schooling. *Reading and Writing*, **25**(8), 1947–1971.

Schwartz, M., **Kozminsky, E.**, & **Leikin, M.** (2009). Delayed acquisition of irregular inflectional morphology in Hebrew in early sequential bilingualism. *International Journal of Bilingualism*, **13**(4), 501–522.

Schwartz, M., **Nir, B.**, **Leikin, M.**, **Levie, R.**, & **Ravid, D.** (2014). The acquisition of noun plurals among early sequential Russian–Hebrew speaking bilinguals: A longitudinal multiple case study. *Heritage Language Journal*, **11**(2), 151–185.

Schwarzwald, O. (2002). *Studies in Hebrew Morphology*. Tel Aviv: The Open University. (in Hebrew)

Shahar-Yames, D., **Eviatar, Z.**, & **Prior, A.** (2018). Separability of lexical and morphological knowledge: Evidence from language minority children. *Frontiers in Psychology*, **9**, 163. https://doi.org/10.3389/fpsyg.2018.00163

Shahar-Yames, D., & **Prior, A.** (2017). Reading development in upper elementary language minority readers of Hebrew: the specific challenge of fluency. *Reading and Writing*, **30**(5), 1065–1087.

Shen, Y. (2023). Issues of Measuring Morphological Awareness Longitudinally. *Reading Psychology*, **44**(2), 175–193.

Sparks, E., & **Deacon, S. H.** (2015). Morphological awareness and vocabulary acquisition: A longitudinal examination of their relationship in English-speaking children. *Applied Psycholinguistics*, **36**(2), 299–321.

Sun, X., **Marks, R. A.**, **Zhang, K.**, **Yu, C.**, **Eggleston, R. L.**, **Nickerson, N.**, **Chou, T.**, **Hu, X.**, **Tardif, T.**, & **Satterfield, T.** (2023). Brain bases of English morphological processing: A comparison between Chinese-English, Spanish-English bilingual, and English monolingual children. *Developmental Science*, **26**(1), e13251.

Tomasello, M. (2001). *First steps toward a usage-based theory of language acquisition.* Cognitive Linguistics. (11), 61–82.

Tyler, A., & **Nagy, W.** (1990). Use of derivational morphology during reading. *Cognition*, **36**(1), 17–34.

Yosefi, G. (2019). *Emotional Processing and Emotional Vocabulary among 4th Grade Bilingual Children*. [Master's thesis] University of Haifa.

Zhang, J., & **Shulley, L.** (2017). Poor comprehenders in English-only and English language learners: influence of morphological analysis during incidental word learning. *Journal of Research in Reading*, **40**(2), 169–183.

Cite this article: Michaly, T., & Prior, A. (2025). Development of derivational morphological knowledge in monolingual and bilingual children: Effects of modality and lexicality. *Journal of Child Language* **52,** 532–557, https://doi.org/10.1017/S0305000924000126