

# From Dichotomy to Divergence: Number/Gender Marking on Hebrew Nouns and Adjectives Across School Ages

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This study investigates the development of plural adjective agreement in Hebrew, focusing on the consolidation of Hebrew number/gender morphology in children and adolescents across the school years in comparison with adults. A total of 240 Hebrew-speaking participants in seven consecutive grade levels (kindergarten to sixth grade) plus a group of 30 adults were administered a set of 32 singular noun-adjective noun phrases, which they had to pluralize. Head nouns were classified by noun gender (masculine and feminine), suffix type (regular and irregular), and stem type (nonchanging and changing). Children's ability to correctly pluralize nouns and adjectives increased markedly from kindergarten to adulthood, whereas reaction time to the correct plural phrase decreased concomitantly. Noun gender, stem, and suffix morphology impacted noun and adjective plural marking as well as reaction time. Results are discussed in view of the critical role of noun gender as a central organizing factor in the development of Hebrew plural marking.

**Keywords** morphology; plural; number; gender; nouns; adjective; first language acquisition; Hebrew

## Introduction

Inflectional morphology emerges early in child language, but it has a long developmental route, with the more complex aspects of the system learned later on during the school years. Hebrew has rich number/gender marking on nouns,

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verbs, and adjectives; thus, plurals are characterized by high token frequency with high prominence in language usage—a constant presence in both speech and writing. Marking plural inflection in Hebrew is a challenging task requiring stable lexical and morphophonological representations as well as grammatical insight. The present study investigates the acquisition of plural morphology in Hebrew-speaking children compared with adults.<sup>1</sup> At the heart of this article is number/gender marking on two linguistic structures in Hebrew—the first as an inherent feature of nouns and the second marking adjectives as a case of head-driven agreement (Corbett, 2006; Dixon & Aikhenvald, 2004), a well-known source of processing errors in Hebrew acquisition and usage (Berman, 1985).

Plural is the most basic morphological marker on nouns: If a language has a single category of morphological marking on the noun, it is grammatical number (Bickel & Nichols, 2007). Grammatical gender is considered as a category most intimately bound up with number in the world's languages (Corbett, 1991, 2007). Plurals exhibit a high degree of semantic predictability and consistency, and they have general and obligatory applicability (Bybee, 1985; Dressler, 2003). These features render plural marking highly frequent and salient for young children, facilitating the initial mapping of meaning or function onto morphological segments. Accordingly, plural emerges as one of the earliest categories in child language development (Aljenaie, 2010; Brown, 1973; Slobin, 1985). At the same time, plural systems in some languages are fraught with structural and morphophonological complexity, inconsistency, and irregularity, which challenge early mastery (Marcus et al., 1992; Ravid & Schiff, 2009). The formation of clear and coherent plural categories requires exposure to a large and variegated array of plural forms. Therefore, across different languages, gaining command of the full complexity of noun plurals is a protracted developmental process that may continue across the school years (Dressler, Ravid, Gillis, & Basboell, 2008; Laaha, Ravid, Korecky-Kröll, Laaha, & Dressler, 2006; Schiff, Ravid, & Levy-Shimon, 2011).

The current study takes as its departure point a view of language as a probabilistic and context-sensitive network that learns the relationship between stems and their inflected forms under constant pressure from linguistic input (Bybee, 2006; Daugherty & Seidenberg, 1994; McClelland & Patterson, 2002; Plunkett & Marchman, 1996). Categories emerge as the learning network improves performance over many learning trials in a gradual, uneven developmental process, when learners integrate different pieces of evidence to establish more and more relationships and regularities (Dąbrowska, 2004; Elman, 2009; Mariscal, 2009). The study contributes to the debate on the nature of morphological (ir)regularity by analyzing the development of noun and adjective pluralization

in Hebrew, for which learning how to correctly form plural forms depends on noun gender and morphophonological structure. Although much research on the development of noun plurals has been carried out in English, the analysis of the richly inflected Hebrew system will be highly informative regarding the format of learners' linguistic representations by showing to what extent it is affected by type frequency and morphophonological characteristics of nouns. Our production-based task makes it possible to test the hypothesis that learning about Hebrew plural marking is a process of reduction in variability (i.e., making increasingly finer-grained generalizations with development). Specifically, plural representations are hypothesized to evolve from a dichotomous perception of number/gender based on salient and frequent noun types to the emergence of diverse, detailed, and abstract representations that support the correct use of new items.

Our main novel argument in this study is that the different distributions of regular and irregular masculine and feminine nouns and the different cues that signal irregularity in stem and suffix predict a particular developmental path with regard to correct plural formation. A critical notion in this context is that of inherent gender—the grammatical classification of non-animate Hebrew nouns as either masculine or feminine. Hebrew is not the only language where grammatical gender cues are important in morpho-syntactic development (see Van Heugten & Shi, 2009, and Van Heugten & Johnson, 2011, for the role of gender in word recognition in French and Dutch, respectively). However, Hebrew gender has critical consequences in agreement marking, because verbs and adjectives agree with the inherent gender of the noun rather than with its form. As we show below, gender is often obscured by misleading phonological and morphological cues: The singular noun can be marked with the opposite gender marking (e.g., *ir* “city,” where the feminine noun takes a masculine form), and it can also have plural marking that diverges from its inherent gender (e.g., *kinor/kinorot* “violin/violins,” where the masculine noun takes a feminine plural marker). Moreover, stem changes in the plural noun stem (e.g., *ir/arim* “city/cities”) can also interfere with the discovery of inherent gender, making it harder to go to the singular form as an indicator of the noun's inherent gender. Thus, adjective agreement might be the only way to determine inherent noun gender, which makes children's learning of this complex system particularly interesting to investigate.

Before presenting the study, three facets of plural marking in the Hebrew noun phrase are discussed in the next sections: (ir)regularity of noun stems and suffixes; distributional patterns of noun gender/number marking; and noun-adjective number/gender agreement. Taken together, they provide the factual

background about the architecture of Hebrew nominal number/gender and an explanatory framework for the particular paths of acquisition found in this study. Note that stress is marked in this article only in nonultimate position, as final stress is default in Hebrew (Segall, Nir-Sagiv, Kishon-Rabin, & Ravid, 2008).

### **(Ir)regularity of Noun Stems and Suffixes**

Pluralizing Hebrew nouns is a linear operation of stem suffixation (e.g., *tapuz/tapuz-im* “orange/oranges”). The plural suffix incorporates number/gender information, marking masculine nouns by *-im*, as in *tik/tikim* “bag/bags,” and feminine nouns by *-ot*, as in *mita/mitot* “bed/beds.” Choice of plural suffix is determined by two features of the singular noun stem: its inherent grammatical gender and its phonological gender marking. Correct plural suffix choice thus crucially depends on identification of noun gender, which in regular nouns is clearly guided by singular phonology. Specifically, masculine nouns mostly end with a consonant, as in, *tik* “bag,” or with a final stressed *-e*, as in *mixse* “lid,” whereas feminine nouns typically end with a stressed *-a*, as in *mita* “bed,” or with *-t*,<sup>2</sup> as in *mapit* “napkin.”

As in many inflectional systems, however, Hebrew plural formation is not always regular. The two components of plural nouns—stems and suffixes—each exhibit separate facets of (ir)regularity in Hebrew. Stem irregularity is expressed in structural changes in the plural stem, resulting in morphological distance between the free singular and bound plural forms. Suffix irregularity is expressed in nouns taking the opposite gender suffix. This dissociation provides a novel perspective on the notion of regularity: Regular English plurals do not undergo stem changes and irregular plurals often do (*man/men*, *foot/feet*), whereas in Hebrew, stem change and regularity of the plural suffix are mostly independent.

### **Stem Change**

Plural suffixation is a resyllabification process in which the suffix attaches to the bare stem ending with a consonant, creating a new final syllable that takes on the main stress of the noun, as in *tik/tik-im* “bag/bags.” When the bare stem ends in a vowel, it is deleted to allow suffix attachment to a consonant, as in masculine *mixse/mixs-im* “lid/lids” or feminine *mita/mit-ót* “bed/beds.” Many stems remain unchanged under suffixation, but others undergo morphophonological change under linear operations (Ravid, 1995). These changes include vowel reduction, deletion, or change; stop/spirant alternation; and *t* omission

(Ravid, 2006). For example, singular masculine *dli* “bucket” changes to *dlay-im* in the plural, whereas feminine *rakévet* “train” changes to plural *rakav-ot*. Stem changes have been shown to hinder and complicate morphological acquisition in Hebrew-speaking children (Levin, Ravid, & Rapaport, 2001; Ravid & Schiff, 2009). This is because it is difficult to relate the form of the singular free stem such as *ish* “man” to its changed bound form in the plural, such as *anash-im* “people” (Schiff et al., 2011).

However, irregularity in stem changes may be tempered by consistency: Stem changes can be predicted with differing degrees of probability. They range from idiosyncratic, as in *isha/nash-im* “woman/women” to expected in certain morphophonological contexts. For example, vowel change, sometimes accompanied by stop/spirant alternation, often occurs in monosyllabic stems, as in *tof /tup-im* “drum/drums.” In some nominal patterns, stem change is completely predictable—for example, singular segolate *CéCeC* stems change to bound plural *CCaC*—as in *kélev/klav-im* “dog/dogs.” Likewise, feminine *-it* suffixed nouns consistently drop the final *t* and replace it with an epenthetic *y*, as in *mapit/mapiy-ot* “napkin/napkins.” Additionally, feminine nouns ending with *-éCet* drop the final *-et*, often accompanied by omission or change of the preceding stressed *é* (*xovéret/xovr-ot* “booklet/booklets” and *rakévet/rakav-ot* “train/trains,” respectively). Thus, Hebrew-speaking children would rely on increasing familiarity with different nouns, their patterns, and suffixes in order to learn about different types of stem changes.

### Suffix Irregularity

Regular plural suffixation occurs when the inherent noun gender coincides with its phonological gender marking, as in masculine *tik/tik-im* “bag/bags” and feminine *mita/mit-ot* “bed/beds.” Irregular plural suffixation results from two kinds of violations of the number/gender link: lexical exceptions and misleading phonological cues (Ravid et al., 2008). In *lexical exceptions*, the noun takes an opposite-gender plural suffix despite clear and consistent phonological gender marking in the singular stem. Thus, consonant-final masculine *sulam* “ladder” takes the irregular feminine plural suffix *sulam-ot* and *á*-final feminine *pnina* “pearl” takes the irregular masculine plural suffix *pnin-im*.

A second type of suffix irregularity, termed here *misleading phonological cues*, occurs when singular stem phonology does not coincide with grammatical gender. For example, feminine *ir* “city” has masculine consonant-final phonology, and it takes the irregular masculine plural form *ar-im*. In the same way, masculine *masa* “journey” has *á*-final pseudofeminine phonology,<sup>3</sup> taking the irregular plural feminine form *masa'-ot*. Misleading phonological marking

of singular stems of course blurs the distinction between masculine and feminine nouns and interferes with learners' category formation and subsequent expectations. To complicate matters further, nouns of both genders with such misleading phonology often take gender-appropriate plural suffixes. For example, feminine *gader* "fence" with masculine consonant-final phonology takes the regular feminine plural form *gder-ot*, and masculine *mada* "science" with *á*-final phonology takes the regular masculine plural *mada'-im*. Although the result is apparently regular pluralization, these last cases cannot be ignored, as they too interfere with the establishment of consistent singular-plural links based on noun gender and eventually impede the consolidation of coherent plural categories.

### Stem Change and Suffix (Ir)regularity

Interestingly, suffix regularity and stem change are often dissociated, which makes it possible to examine their separate effects on learning Hebrew noun plurals. Thus, both regular and irregular suffixes attach to nonchanging and changing stems of both genders. For example, compare the two regular masculine nouns *nof/nof-im* "landscape/landscapes" and *tof/tup-im* "drum/drums." The former does not undergo stem change, whereas the latter does. In the same way, compare irregular feminine nouns *mila/mil-im* "word/words," with no stem change, and *isha/nash-im* "woman/women," with stem change. From a different perspective, the large and dense nominal *CéCeC* pattern, which consistently changes to plural *CCaC-*, takes both regular (e.g., *kétem/ktam-im* "stain/stains") and irregular (e.g., *régesh/regash-ot* "feeling/feelings") plural suffixation. However, here, too, consistent links between stem change and suffix regularity can be drawn in some cases. For example, the masculine pattern *CiC(a)Con<sup>4</sup>* consistently requires a specific stem change and the irregular feminine suffix *-ot*, as in *nisayon/nisyon-ot* "attempt/attempts." Such links may serve to reduce input variability and help learners detect regularities in plural formation with extended language experience.

### Developmental Patterns

Evidence for the early emergence of Hebrew noun plurals comes from a variety of sources, including longitudinal case studies (Herzberg, 2010; Levy, 1980), sampling of spontaneous speech (Berman, 1985; Ravid, 1995), and cross-sectional experimentation in Hebrew-speaking children (Berman, 1981; Lavie, 2006). A recent study shows that most plural nouns in Hebrew child-directed speech and production by toddlers have masculine singular and plural phonology, nonchanging stems, and regular suffixes (Ravid et al., 2008). Between ages 2 and 4, children start producing the less frequent feminine *-ot*

suffix and performing the pervasive *a*-deletion stem change on plural nouns (Berman, 1981). A detailed account of the acquisition of Hebrew plural nouns in preschoolers can be found in Ravid and Schiff (2009) and in Schiff et al. (2011). Plural nouns requiring major or less predictable stem changes have a long developmental route across the school years (Kaplan, 2008; Lavie, 2006; Ravid, 1995) and constitute one of the foci of the current study.

### Distributional Patterns of Noun Gender/Number Marking

Irregular plural suffixation disrupts the transparent and consistent link between noun phonology and inherent grammatical gender. Here, too, the occurrence of irregular suffixation is not completely unpredictable, being unevenly distributed across the two genders and relying to some extent on phonological factors. As distributions generate statistical expectations and participate in category construction, they can help or hinder learners in predicting irregular pluralization. In general, masculine nouns are more numerous than feminine nouns in the core, everyday lexicon, a stable feature of Hebrew in both phylogenetic and ontogenetic terms (Ravid et al., 2008; Tubul, 2003). Subsequently, masculine nouns with feminine plural suffixes are much more numerous than the opposite case of feminine nouns with masculine plural suffixes (Levy, 1980). For learners, this means that masculine nouns are more likely to take irregular plural suffixation than feminine nouns.

This bias for irregular masculines is enhanced by the distributions of specific types of irregular plural suffixes in the two genders. Where transparent phonological marking coincides with grammatical gender (i.e., lexical exceptions), feminine stems are less likely to take on irregular masculine suffixation than the opposite case. There are very few overtly marked feminine nouns that take the irregular masculine *-im* plural form. Virtually all of these feminine irregulars are *a*-final, as in *shana/shanim* “year/years,” whereas feminine nouns with final *-t* (e.g., *sakit* “baggy”)—the other type of overt feminine phonology—almost never take an irregular plural form.<sup>5</sup> Thus, irregular plurals of overtly marked feminines are extremely scarce, which contributes to making irregular feminine lexical exceptions hard to learn. In contrast, numerous clearly marked masculine nouns have irregular feminine suffixes (e.g., *kol/kolot* “voice/voices”). Importantly, irregular masculines tend to be cued by final voiced segments (Ravid & Schiff, 2009): Most irregular masculine nouns end with sonorant segments (e.g., *kinor/kinor-ot* “violin/violins,” *olam/olam-ot* “world/worlds,” or *kace<sup>6</sup>/kcav-ot* “edge/edges”—including the aforementioned *CiCaCon* pattern: e.g., *zikaron/zikron-ot* “memory/memories”) or with other

final voiced segments (*lev/levav-ot* “heart/hearts” or *gag/gag-ot* “roof/roofs”). A few irregular masculines end with unvoiced segments often preceded by *o* (*of/of-ot* “fowl/fowls,” *ot/ot-ot* “signal/signals”).<sup>7</sup> Thus, in addition to the general distributions of masculine and feminine nouns, overt gender marking consistent with inherent grammatical gender increases the chance that irregular lexical-exception plural marking would be found in masculine rather than feminine nouns.

This tendency for masculine irregularity is enhanced in the distributions of misleading phonological cues, for which overt phonological marking of the singular stem clashes with its grammatical gender. The core Hebrew lexicon includes numerous feminine nouns (including animate nouns) ending in a consonant—that is, displaying apparent masculine phonology (Tubul, 2003), as in *em* “mother,” *yad* “hand,” *dérex* “way,” *xacer* “yard,” *ez* “she-goat,” *éven* “stone,” *ir* “city,” or *cipor* “bird.” Of these pseudomaskuline feminines, some take the masculine plural form (e.g., *ir/ar-im* “city/cities”), whereas others take the feminine plural form (*xacer/xacer-ot* “yard/yards”). All of them, however, behave like masculine nouns, in that the plural suffix attaches directly to the final consonant. This means that Hebrew-speaking children encounter many more nouns with basic masculine than feminine phonology, and, consequently, feminine gender needs to be established by other means, such as agreement with verbs and adjectives.

In contrast, not many singular masculine nouns have feminine phonology, and most of them are not part of the core nominal lexicon. A few abstract nouns end with final stressed *a*<sup>8</sup>; for instance, *cava* “army,” *mada* “science,” or *meida* “information.” Equally few masculine nouns have final *-t*, such as *yalkut* “sachel,” *sharvit* “scepter,” or *mashot* “oar.” However, unlike pseudomaskuline feminines, all pseudofeminine masculines exhibit masculine morphophonological behavior: Whereas real feminines omit the suffixal *a* and *t* before the plural suffix (e.g., *mana/man-ot* “portion/portions”; *axot/axay-ot* “sister/sisters”), pseudofeminine *a* and *t*, not being morphological components, are retained before the plural suffix, as in *mada/mada'-im* “science/sciences” and *mashot/meshot-im* “oar/oars.” This is because all such masculine nouns only mimic feminine phonology while having masculine root morphology, as evidenced by their written forms (Ravid, 2005, 2012). Thus, with the advent of literacy, these nouns will be even more robustly identified as masculine rather than feminine (Ravid, 1995). The generalization elicited from these distributions is a stronger link between masculine phonology and gender, and a weaker link between feminine gender and phonology.



To summarize, feminine nouns should be more difficult than masculine nouns to identify and learn in general, due to the large number of feminine nouns with robust and consistent masculine phonology and behavior, contrasted with the small number of masculine nouns with pseudofeminine form and behavior. Moreover, due to their larger number and salient voiced phonology, masculine irregular plurals are easier to learn than feminine irregulars.

Gender interfaces to some extent with stem changes as well. Stem changes might also be associated more with masculine than feminine nouns. The greater number of masculine nouns gives rise to more diversity of stem changes in masculine nouns—vowel deletion (*makel/makl-ot* “stick/sticks”), vowel change (*ken/kin-im* “nest/nests”), stop/spirant alternation (*af/ap-im* “nose/noses”), and full stem changes such as in *cad/cdad-im* “side/sides.” The vast masculine *CéCeC* class (Avineri, 1976) undergoes regular and consistent change, which is learned very early (Ravid, 1995). Many of these nouns are part of the early lexicons of Hebrew-speaking children. In contrast, the most frequent stem change associated with feminine nouns is final *t*-deletion (*xanut/xanuy-ot* “shop/shops”), accompanied in *-éCet* stems by vowel change to *-a* (e.g., *magévet/magav-ot* “towel/towels”). Apart from this, almost all *-t* final and the majority of *-a* final feminine nouns are nonstem changing in the plural. This means that children have less chance to encounter changing feminine stems and might associate stem change more with masculine forms.

## Noun-Adjective Number/Gender Agreement

Berman (1985) had suggested that

Perhaps the most complex morphosyntactic task for the Israeli child, and one which is as crucial as a developmental criterion for Hebrew as is the acquisition of auxiliary patterning in English, is the learning of grammatical AGREEMENT – from subject to main-verb. . . as well as from the head noun to adjectives . . . in number, gender and definiteness. (p. 273)

Therefore, a third perspective on Hebrew pluralization we explore in this study is the obligatory agreement marking of plural inflection on adjectives, and we are interested in probing how the factors of stem and suffix irregularity and their relationship to gender classes, as reviewed thus far, might affect learning how adjectives agree with plural nouns.

Adjectives are a less primary lexical class than nouns, denoting noun attributes and properties in two principal syntactic functions: predicative and

attributive. The dependence of adjectives on nouns is demonstrated in a range of studies showing that preschoolers' very grasp of adjectives hinges on the semantic and grammatical properties of nouns (Diesendruck, Hall, & Graham, 2006; Mintz, 2005; Ninio, 2004; Waxman & Klibanoff, 2000). As relational terms, adjectives show up later in child speech than nouns (Casseli, Bates, Casadio, & Fenson, 1995; Rice, 1990), and they constitute a low-frequency class compared to other content words in children's early lexicons (Sandhofer, Smith, & Luo, 2000; Valian, 1986). By age 4, adjectives have consolidated and diversified in children's productions (Barrett, 1995; Blackwell, 2005; Ravid & Nir, 2000), although the fully mature semantic, syntactic, and morphological richness and diversity of adjectives is reached only by late adolescence (Ravid & Levie, 2010).

A major issue in the current study is how children learn to mark number/gender agreement on adjectives. As noted by Greenberg (1963), in languages in which the adjective follows the noun (such as Hebrew), it expresses all of the inflectional classes marked by the noun (Keenan, 1976; Markman, 1989). Where the noun is not systematically marked for gender, the form of the adjective might be the only way to determine inherent noun gender (Corbett, 1991). In a survey of children's acquisition of adjective agreement from French to Sesotho, Clark (1998) noted that the distribution of agreement markers helps children learn about elements that belong together semantically or grammatically, such as number and gender. Clark showed that, across languages, children mainly rely on phonological cues to agreement, in addition to other sources of information such as semantics and discourse. Recent studies analyzing cue types in language development concur that phonological and distributional properties of words interact in learning about grammatical categories (Monaghan, Chater, & Christiansen, 2005; Monaghan, Christiansen, & Chater, 2007).

Two new studies illustrated this generalization. A study of Spanish acquisition (Mariscal, 2009) showed that children construct abstract agreement categories based on a dynamically changing confluence of sources in the input, such as noun phonology and the shape of determiners, pronouns, and adjectives. A study on Lithuanian agreement (Savickiene, Kempe, & Brooks, 2009) found that children make use of the mediating factor of diminutive morphology in learning to mark adjective agreement. Both studies interpreted their results as showing that children store representations of units of various sizes and form generalizations at differing degrees of abstraction—rather than applying a rule to all members of a symbolic category (and the same seems to be true of adult second language learners; see Brooks, Kempe, & Donachie, 2011, on Russian).

Hebrew, as we have already seen, has both types of nouns—explicitly and nonexplicitly marked for gender (Corbett, 1991)—thus, marking adjective agreement is a challenging task requiring morphophonological and grammatical insight involving knowledge about the patterning of gender/number marking on nouns. Adjective agreement emerges and is learned in Hebrew during the consolidation of clause syntax in the third year of life (Berman, 1985; Levy, 1980). Singular gender noun-adjective agreement precedes plural marking on adjectives, which rarely occurs in early child speech. Berman (1985) noted that children often erroneously mark adjective agreement with irregular noun plurals; however no systematic study to date has examined the development of adjective agreement in the plural Hebrew noun phrase.

In the current study, we focus on attributive adjectives in the noun phrase, which follow the head noun and obligatorily agree with it in number and gender<sup>9</sup> (e.g., *arac-ot rexok-ot* “countries, F distant, Pl, F”<sup>10</sup>). The crucial point here is that agreement relies on the inherent grammatical properties of the noun rather than on its form. Even for straightforward cases of regular inflection, marking plural agreement on the adjective is not an easy task, as it requires paying simultaneous attention to both components in order to match the adjective plural suffix with that of the head noun.

The problem resides in cases of clash between plural noun suffix and noun gender. For example, masculine *kir* “wall” takes an irregular feminine plural suffix *-ot* to yield *kirot*, but the plural adjective would agree with the masculine gender of the noun *kir* “wall” rather than with its plural suffix. The plural N-A phrase “tall walls” would thus be *kir-ot gvoh-im*, with conflicting plural suffixes on the noun and on the adjective. In the same way, because feminine *shana* “year” takes an irregular suffix, the plural N-A phrase “good years” would be the conflicting *shan-im tov-ot*. The analysis of noun gender/number marking in the previous sections indicates that the likelihood of *N-im A-ot* and *N-ot A-im* is not equal. The number of irregular feminine nouns (both transparently marked lexical exceptions such as *pnina/pnin-im* “pearl/pearls” and pseudomasculines such as *ir/ar-im* “city/cities”) is small. In contrast, the number of irregular lexical exception masculines (e.g., *sulam/sulam-ot* “ladder/ladders”), including pseudofeminines taking irregular suffixes (e.g., *cava/cva'-ot* “army/armies”) is much larger. Therefore, plural phrases with inconsistent *N-ot A-im* masculine agreement are more likely to occur in the input than inconsistent feminine *N-im A-ot* plural phrases.

Noun stem changes add complication to the agreement process in the production of the N-A plural phrase. When the plural suffix is regular, it is copied from the noun to the adjective. The need to check noun gender arises only when

the suffix is irregular, as in *sulam-ot gvoh-im* “high ladders.” In such cases, the singular noun stem needs to be retrieved in order to determine the adjective suffix. In the case of nonstem changing *sulam/sulam-ot* “ladder/ladders,” gender determination is easy. However, where the stem changes, as in *kace/kcav-ot* “edge/edges,” the morphological distance between the free and bound stems interferes with the retrieval process and hence with suffix determination. This should be especially daunting in changing feminine stems that successfully mimic masculine phonology, such as *ir/ar-im* “city/ cities.”

## The Present Study

The aim of this study is to investigate the impact of Hebrew noun morphology and, specifically, suffix (ir)regularity and stem transparency/opacity on grade school children’s developing ability to change singular to plural noun phrases. Hebrew number morphology, with its multiple and often conflicting gender cues, provides a testing ground for refining our understanding of inflectional learning.

Based on the analyses presented in the previous sections, we make the following predictions. Overall, we predict (a) improvement with age and schooling on producing noun and adjective plurals, especially with irregular suffixes and/or changing stems (Ravid & Schiff, 2009). Regarding nouns, we predict (b) lower scores on feminine than masculine gender in general; (c) irregular masculines should be easier than irregular feminines; (d) lower scores on nouns with stem changes; and (e) irregular masculines with stem changes should be easier than stem-changed feminines. Regarding adjectives, we predict (f) lower success with feminine nouns; (g) lower success with changed-stem nouns; (h) lower success with irregular suffixes; and (i) least success with nouns combining stem change and irregular suffixation, especially with feminine nouns. In order to address these predictions, we analyze the accuracy of marking plural suffixes on nouns and marking plural agreement on adjectives, as well as reaction time to pluralizing the noun phrase.

## Method

### Participants

Eight potential participants with reported emotional problems and/or attentional deficits were excluded from the study population before the beginning of the study. The final study population consisted of 240 participants, 30 in each group, in seven consecutive grade levels in an elementary public school in the center of Israel (kindergarteners aged 5–6, first graders aged 6–7, second

graders aged 7–8, third graders aged 8–9, fourth graders aged 9–10, fifth graders aged 10–11, and sixth graders aged 11–12), plus a control group of 30 adults, students at a research university in the center of Israel, aged 24–30. Participants were all native, monolingual speakers of Hebrew with no diagnosed hearing impairment, learning, language, or reading disability, from middle and high socioeconomic status. In each group we made an effort to include a similar number of males and females.

### Materials

The task consisted of 32 singular noun-adjective pairs (e.g., *tof gadol* “drum big = big drum” or *ir gdola* “city big, Fm = big city”; see the appendix for a full list of the target items). Nouns were classified by gender (half of the nouns were masculine, and half were feminine), suffix type (regular and irregular), and stem type (nonchanging and changing stems). In the absence of oral language frequency lists for Hebrew,<sup>11</sup> nouns were selected by the following process. First, 30 grade school teachers familiar with grade schoolers’ lexical abilities were asked to grade a list of 50 nouns taken from grade school texts on a scale of 1–5 in terms of frequency. We discarded very rare and very frequent words and ended up with a list of nouns that had received the score of 3–3.5 out of 5 on the scale.

Only four adjectives were used in conjunction with all the nouns—*gadol* “big,” *lavan* “white,” *tov* “good,” and *shaket* “quiet”—all well-known, everyday adjectives familiar to young children. The fact that adjectives undergo the same stem changes as nouns was taken into consideration. The four adjectives had either nonchanging stems (*tov* “good”) or underwent *a*-deletion in both feminine singular and plural form (as in *gadol/gdol-a/gdol-im* “big/F/Pl”). *A*-deletion is the earliest learned stem change in Hebrew-speaking children (Ravid, 1995; Ravid & Shlesinger, 2001). Because we had both masculine and feminine nouns, adjectives in the study occurred in both free and changed forms (e.g., both *lavan* “white” and feminine *levan-a*) and thus did not constitute a problem in pluralization. None of the children who participated in the study erred on vowel deletion in the plural adjectives. Table 1 presents the structure of the noun categories, with examples.

### Procedure

Participants were tested orally and individually by computer in the spring, 3 months before the end of the school year, in a quiet room at school. All stimuli were presented in auditory form by the computer software program SuperLab (<http://www.superlab.com/>). Each participant was presented with a

**Table 1** Structure of the four noun categories in the noun-adjective task

Stem type	Nonchanging stem		Changing stem	
	Masculine	Feminine	Masculine	Feminine
Regular	<i>tik</i> “bag”	<i>matana</i> “present”	<i>tof</i> “drum”	<i>dim’a</i> “tear”
suffix	<i>tik-im</i> “bags”	<i>matan-ot</i> “presents”	<i>tup-im</i> “drums”	<i>dma’-ot</i> “tears”
Irregular	<i>kinor</i> “violin”	<i>beyca</i> “egg”	<i>kace</i> “edge”	<i>ir</i> “city”
suffix	<i>kinor-ot</i> “violins”	<i>beyc-im</i> “eggs”	<i>kcav-ot</i> “edges”	<i>ar-im</i> “cities”

set of four training noun-adjective pairs, two masculine and two feminine, two with regular suffixes and two with irregular suffixes, and two with nonchanging and two with changing stems, such as *ner lavan* “candle white–” and many *ner-ot levan-im* “candles white, Pl.” After training, the actual experiment started. Participants heard 32 singular noun-adjective pairs as stimuli. Each singular NP was presented in auditory form, and the student was asked to say it aloud in the plural. For example, given the stimulus *olam gadol* “world big,” participants were expected to say *olam-ot gdol-im* “worlds big, Pl”—that is, to pluralize the noun and to mark plural agreement on the adjective. Each response was audio-taped and transcribed by attending investigators (masters students majoring in Education). The computer software marked the onset of the participant’s response and controlled the presentation of the stimuli and the online recording of the responses. All participants completed the task. No participant failed to create any of the full plural N-A phrases.

### Analysis and Scoring

Nouns and adjectives were scored separately. Noun plurals were scored on correctness (accuracy) of stem and plural suffix. Only fully correct plural nouns (i.e., correctly changed stem and correct suffix) were considered accurate. Adjectives were scored on correctness of suffix. All scores were converted into percentages. When 15% of the recorded responses were checked by two different judges to ensure reliability, virtually all were found correctly coded ( $\alpha = .92$ ). In addition, we measured reaction time to producing the fully correct plural noun phrase.

### Results

We present results in three subsections. First, we report the results for accuracy of noun plurals. This is followed by the results for accuracy in applying plural

	K	G1	G2	G3	G4	G5	G6	Adults
K	-							
G1		-						
G2			-					
G3				-				
G4					-			
G5						-		
G6							-	
Adults								-

**Figure 1** Post hoc pairwise comparisons between grade levels in the noun plurals. Shaded cells indicate significant differences at the .05 level.

agreement to adjectives. Finally, we report reaction time to producing the whole plural noun phrase.

**Noun Plurals**

Table 2 presents correct responses on the four categories of noun plurals in the eight age groups.

We conducted a four-way ANOVA of Grade (8) × Noun gender (2) × Stem type (2) × Suffix type (2) on the data in Table 2. All variables were found to be significant. Grade level was significant,  $F(7, 232) = 82.49, p < .001, \eta_p^2 = .72$ , showing that correct performance increased with grade level. Figure 1 shows the pairwise Bonferroni post hoc analyses at the .05 level. Kindergarteners and first graders were not statistically different, and the same applied to adults and sixth graders; third graders differed from sixth graders, with second to sixth graders in between.

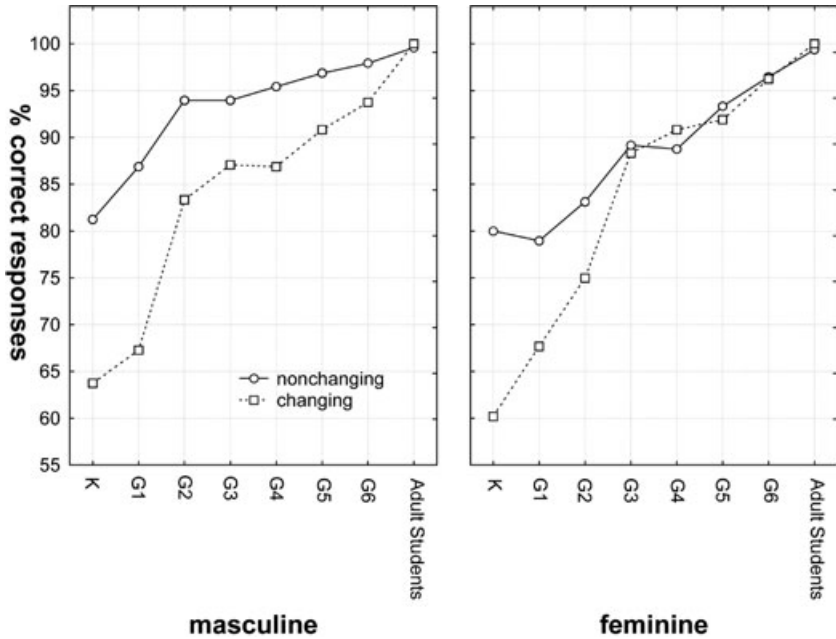
Noun gender was significant,  $F(1, 232) = 21.7, p < .001, \eta_p^2 = .86$ . As predicted, masculine nouns scored higher ( $M = 88.67$ ) than feminine nouns ( $M = 86.21$ ). Stem type was also significant,  $F(1, 232) = 211.43, p < .001, \eta_p^2 = .48$ . As predicted, nonchanging stems scored higher ( $M = 90.94$ ) than changing stems ( $M = 83.95$ ). So was suffix type,  $F(1, 232) = 769.06, p < .001, \eta_p^2 = .77$ . Once again as predicted, regular suffixes scored higher ( $M = 95.53$ ) than irregular suffixes ( $M = 79.35$ ).

**Table 2** Mean correct percentages and standard deviations on the formation of noun plurals, by noun gender (masculine and feminine), noun category (stem and suffix type), and grade level

Noun category Grade	Regular Suffix Nonchanging Stem		Regular Suffix Changing Stem		Irregular Suffix Nonchanging Stem		Irregular Suffix Changing Stem	
	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.
Kindergarten	98.33 (4.32)	98.33 (4.32)	79.17 (26.33)	79.17 (12.85)	64.17 (17.60)	61.67 (15.37)	48.33 (14.95)	41.25 (18.32)
First grade	99.58 (2.28)	99.58 (2.28)	76.25 (26.33)	85.83 (9.70)	74.17 (15.02)	58.33 (10.03)	58.33 (16.19)	49.58 (18.99)
Second grade	100 (0)	98.75 (3.81)	92.08 (17.52)	88.33 (10.35)	87.92 (14.49)	67.50 (17.55)	74.58 (14.86)	61.67 (18.26)
Third grade	99.58 (2.28)	99.58 (2.28)	95.83 (13.27)	95.00 (6.23)	88.33 (10.85)	78.75 (15.79)	78.33 (17.35)	81.67 (20.43)
Fourth grade	100 (0)	100 (0)	91.67 (18.37)	96.67 (5.62)	90.83 (11.34)	77.50 (15.19)	82.08 (20.15)	85.00 (18.11)
Fifth grade	99.58 (2.28)	99.58 (2.28)	94.17 (16.65)	97.92 (4.74)	94.17 (6.34)	87.08 (13.33)	87.50 (12.71)	85.83 (14.95)
Sixth grade	100 (0)	99.58 (2.28)	95.83 (12.85)	97.08 (6.30)	95.83 (5.99)	93.33 (11.24)	91.67 (11.53)	95.42 (9.56)
Adult students	99.58 (2.28)	100 (0)	100 (0)	100 (0)	99.58 (2.28)	98.75 (3.81)	100 (0)	100 (0)

*Note.* Masc. = masculine; Fem. = feminine.

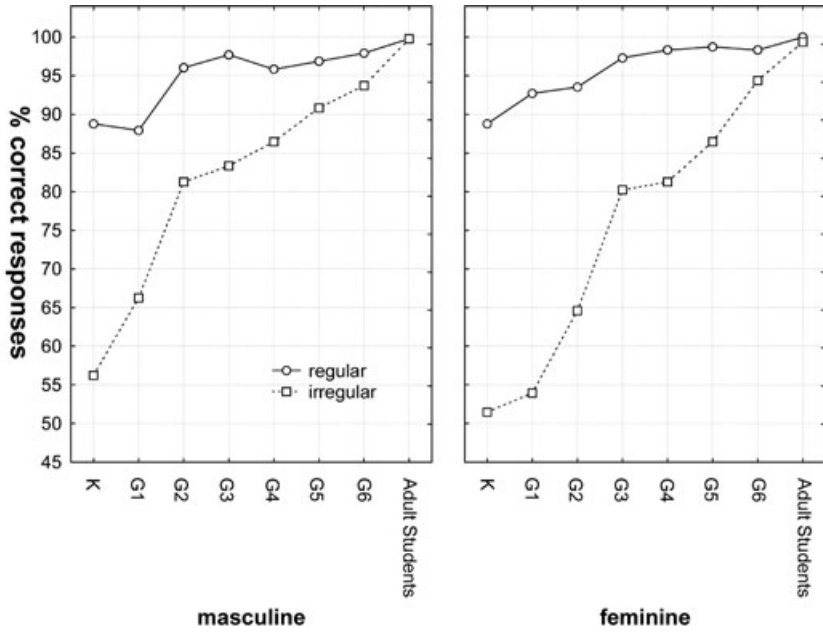




**Figure 2** Interaction of grade level (eight groups), noun gender (masculine, feminine), and stem type (nonchanging, changing) on correct noun plurals.

Almost all two-way interactions were found to be significant: Grade  $\times$  Stem type,  $F(7, 232) = 25.21, p < .001, \eta_p^2 = .43$ ; Grade  $\times$  Suffix type,  $F(7, 232) = 54.33, p < .001, \eta_p^2 = .62$ ; Grade  $\times$  Noun gender,  $F(7, 232) = 4.48, p < .001, \eta_p^2 = .12$ ; Stem type  $\times$  Noun gender,  $F(1, 232) = 18.43, p < .001, \eta_p^2 = .74$ ; and Suffix type  $\times$  Noun gender,  $F(1, 232) = 31.41, p < .001, \eta_p^2 = .12$ . The Stem  $\times$  Suffix interaction was not significant. The three three-way interactions that emerged (presented in Figures 2, 3, and 4, respectively) showed the extent to which gender interfaces with noun morphology and development: Grade  $\times$  Noun gender  $\times$  Stem type,  $F(7, 232) = 2.24, p < .04, \eta_p^2 = .63$ ; Grade  $\times$  Noun gender  $\times$  Suffix type,  $F(7, 232) = 2.24, p < .04, \eta_p^2 = .63$ ; and Noun gender  $\times$  Stem type  $\times$  Suffix type,  $F(7, 232) = 2.24, p < .04, \eta_p^2 = .63$ . The four-way interaction was not significant.

The Bonferroni analysis results of the Grade  $\times$  Noun gender  $\times$  Stem type interaction were as follows. In masculine nouns, the difference between changing and nonchanging stems is retained until adulthood, whereas feminine stems of both types converge in the third grade. Changing stems have a similar

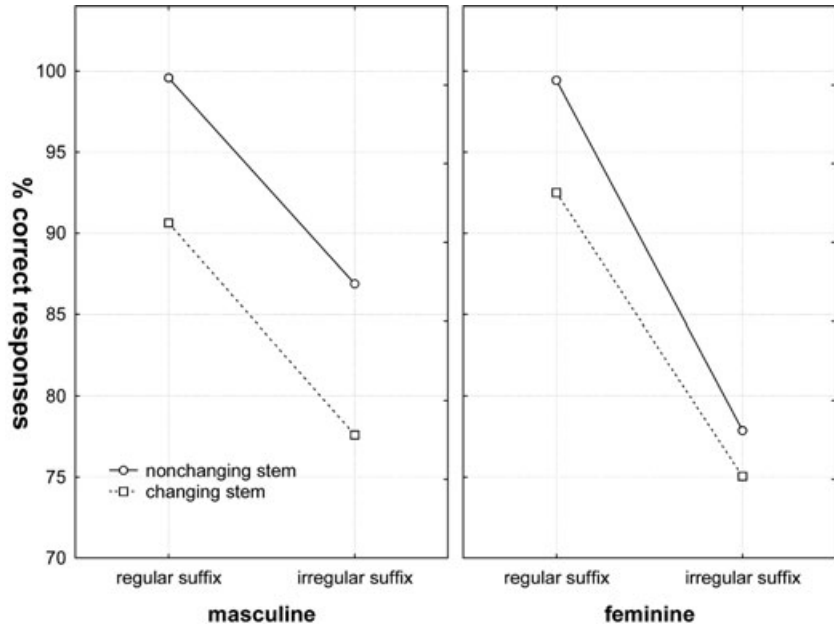


**Figure 3** Interaction of grade level (eight groups), noun gender (masculine, feminine), and suffix type (regular, irregular) on correct noun plurals.

trajectory in both genders, following a long and protracted developmental route. However, masculine nonchanging stems reach 95% by the second grade, whereas feminine nonchanging stems lag behind and reach 95% only 3 years later, in the fifth grade.

The Bonferroni analysis results of the Grade  $\times$  Noun gender  $\times$  Suffix type interaction were as follows. In both masculine and feminine nouns, regular suffixes attain close to 90% by kindergarten. The difference lies in the irregular suffixes. In feminine nouns, irregular suffixes start lower than in masculine nouns. Moreover, irregular masculines attain about 80% by the second grade, whereas irregular feminines attain the same success score a year later by the third grade. In both genders, the gap between regular and irregular nouns is closed only at adulthood.

The Bonferroni analysis results of the Noun gender  $\times$  Stem type  $\times$  Suffix type interaction were as follows. In masculines, regular and irregular nouns show the same gap between changing and nonchanging stems. In feminines, the gap between changing and nonchanging stems is much smaller in irregular



**Figure 4** Interaction of noun gender (masculine, feminine), stem type (nonchanging, changing), and suffix type (regular, irregular) on correct noun plurals.

nouns than in regular nouns. Moreover, regular nouns of both genders do not differ, whereas feminine irregulars achieve a lower score than masculine irregulars, and the difference is especially marked on nonchanging stems. In other words, feminine irregulars are hardest, regardless of the stem.

**Adjective Plural Marking**

Table 3 presents the correct responses on plural marking of adjectives in the eight age groups in light of noun gender and the four categories of noun plurals.

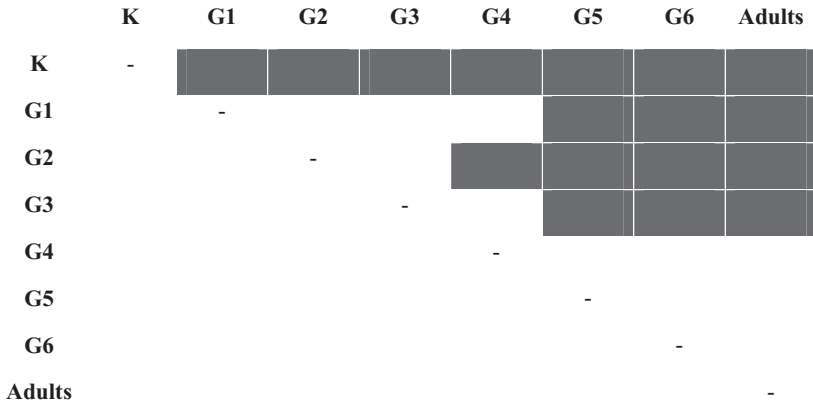
We conducted a four-way ANOVA of Grade (8) × Noun gender (2) × Stem type (2) × Suffix type (2) on the data in Table 3. Grade level was significant,  $F(7, 232) = 24.06, p < .001, \eta_p^2 = .42$ , showing that correct performance increased with grade level. Figure 5 shows the pairwise Bonferroni post hoc analyses at the .05 level. Here, kindergarteners formed a separate group, fifth graders to adults differed from the younger first to third grades, with fourth grader in between.

All effects of noun morphology on correct plural adjective formation were significant. Noun gender was significant, although effect size was small,  $F(1,$

**Table 3** Mean correct percentages and standard deviations on the formation of plural adjectives, by noun gender, noun category (stem and suffix type), and grade level

Noun category Grade	Regular Suffix Nonchanging Stem		Regular Suffix Changing Stem		Irregular Suffix Nonchanging Stem		Irregular Suffix Changing Stem	
	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.
Kindergarten	99.17 (4.56)	88.33 (23.43)	92.50 (13.37)	84.16 (21.26)	70.00 (29.65)	80.83 (24.28)	72.50 (28.12)	60.83 (27.61)
First grade	99.17 (4.56)	97.50 (10.06)	97.50 (7.63)	95.00 (10.17)	76.67 (22.68)	92.50 (13.37)	78.33 (24.33)	70.83 (29.42)
Second grade	100 (0)	95.00 (12.11)	98.33 (9.13)	90.00 (19.25)	83.33 (23.06)	85.00 (20.34)	72.50 (23.99)	69.17 (26.00)
Third grade	100 (0)	95.83 (11.53)	97.50 (10.06)	94.17 (12.60)	91.67 (16.52)	88.33 (17.04)	88.33 (18.26)	73.33 (21.71)
Fourth grade	99.17 (4.56)	100 (0)	98.33 (6.34)	99.17 (4.56)	98.33 (9.13)	85.00 (18.10)	86.67 (15.72)	81.67 (21.71)
Fifth grade	99.17 (4.56)	100 (0)	99.17 (4.56)	99.17 (4.56)	96.67 (8.64)	91.67 (21.10)	92.50 (14.90)	93.33 (14.58)
Sixth grade	100 (0)	96.67 (8.64)	98.33 (6.34)	99.17 (4.56)	96.67 (8.64)	90.83 (20.22)	89.17 (18.20)	91.67 (16.52)
Adult students	99.17 (4.56)	100 (0)	100 (0)	100 (0)	100 (0)	98.33 (6.34)	97.50 (7.63)	95.00 (10.17)

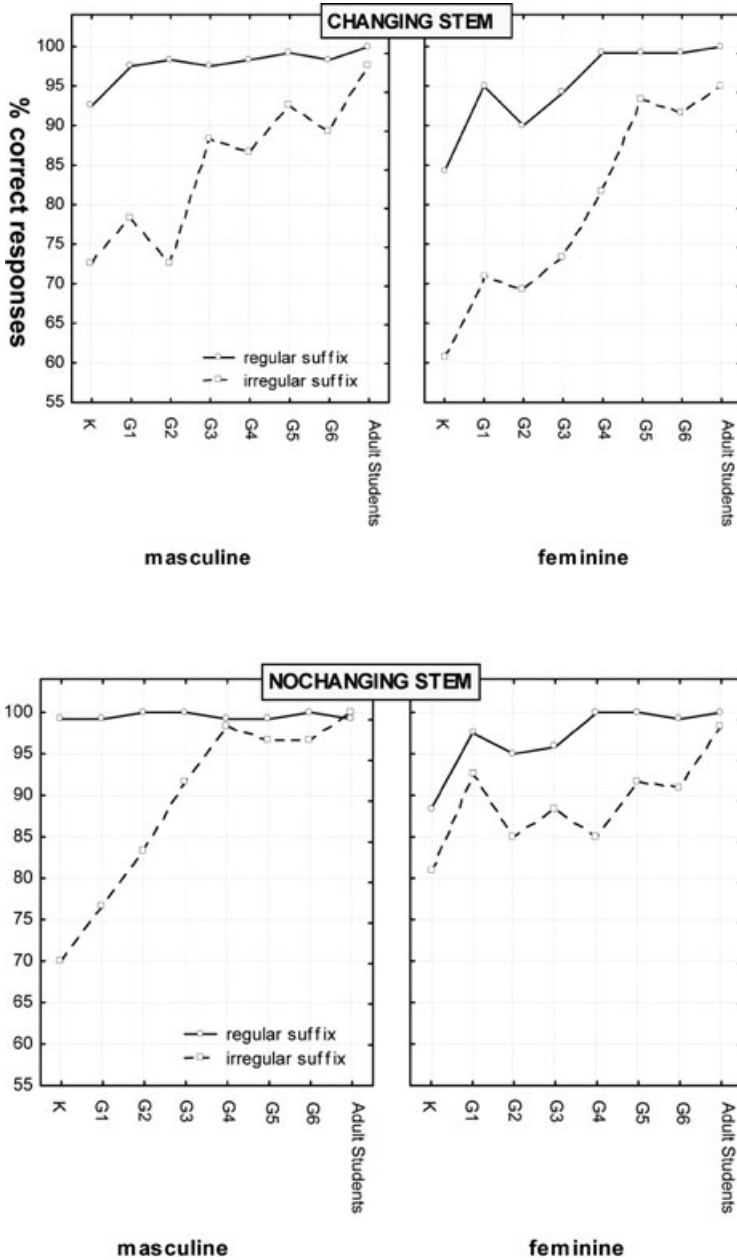
*Note.* Masc. = masculine; Fem. = feminine.



**Figure 5** Post hoc pairwise comparisons between grade levels in the plural adjectives. Shaded cells indicate significant differences at the .05 level.

232) = 6.67,  $p < .02$ ,  $\eta_p^2 = .03$ . As predicted, adjectives in agreement with masculine nouns scored higher ( $M = 92.76$ ) than with feminine nouns ( $M = 90.16$ ). Stem type was also significant,  $F(1, 232) = 69.25, p < .001, \eta_p^2 = .23$ . As predicted, adjectives in agreement with plural nouns having nonchanging stems scored higher ( $M = 93.67$ ) than those with changing stems ( $M = 89.25$ ). So was suffix type,  $F(1, 232) = 234.77, p < .001, \eta_p^2 = .50$ . As predicted, adjectives in agreement with nouns bearing regular suffixes scored higher ( $M = 97.32$ ) than irregular suffixes ( $M = 85.6$ ).

Again, most interactions were significant: Grade  $\times$  Stem type,  $F(7, 232) = 3.47, p < .002, \eta_p^2 = .10$ ; Grade  $\times$  Suffix type,  $F(7, 232) = 9.08, p < .001, \eta_p^2 = .22$ ; Stem type  $\times$  Suffix type,  $F(1, 232) = 26.06, p < .001, \eta_p^2 = .10$ ; and Noun gender  $\times$  Suffix type,  $F(1, 232) = 6.49, p < .02, \eta_p^2 = .03$ . The Grade  $\times$  Noun gender interaction was not significant, nor was the Grade  $\times$  Stem  $\times$  Suffix interaction. All other three-way interactions were significant: Grade  $\times$  Noun gender  $\times$  Stem type,  $F(7, 232) = 4.92, p < .001, \eta_p^2 = .13$ , Grade  $\times$  Noun gender  $\times$  Suffix type,  $F(7, 232) = 2.86, p < .008, \eta_p^2 = .08$ , and Noun gender  $\times$  Stem type  $\times$  Suffix type,  $F(7, 232) = 5.73, p < .02, \eta_p^2 = .02$ . Most informative was the significant four-way interaction of Grade  $\times$  Noun gender  $\times$  Stem type  $\times$  Suffix type,  $F(7, 232) = 5.11, p < .001, \eta_p^2 = .13$ , presented in Figure 6.



**Figure 6** Interaction among grade level, noun gender, stem type, and suffix type on correct plural adjectives.

The Bonferroni analysis results of the interaction of Grade  $\times$  Noun gender  $\times$  Stem type  $\times$  Suffix type were as follows. For nonchanging stems, adjectives agreeing with regular masculine nouns reach ceiling from kindergarten, whereas agreement with irregular masculine nouns is a protracted developmental process that converges with regulars in the fourth grade. The picture for feminine agreement is very different: Whereas regular suffixed nouns show correct agreement by the first grade, irregular feminines practically stay in place and converge with regulars only by adulthood. For changing stems, adjectives agreeing with regular masculine nouns show a similar picture as in nonchanging stems; however, agreement with irregular masculines is more gradual and convergence comes only by adulthood. Adjectives in agreement with regular feminine nouns show a similar picture as with nonchanging stems; however, agreement with irregular feminine nouns with changing stems is a long and protracted developmental process, and even adults do not reach 100% success. When comparing the two types of stems and two suffix types, changing masculine irregulars take longer to achieve correct agreement than nonchanging masculine irregulars. By contrast, changing feminine irregulars (a) start much lower than nonchanging feminine irregulars and (b) do not converge with regulars, whereas nonchanging feminine irregulars do.

### Reaction Time to Pluralizing the Noun Phrase

We measured the reaction time (RT) to producing the correct plural noun phrase. Table 4 presents the mean RTs and standard deviations by grade level, noun gender, and noun categories.

We conducted a four-way ANOVA of Grade (8)  $\times$  Noun gender (2)  $\times$  Stem type (2)  $\times$  Suffix type (2) on the data in Table 4. Grade level was significant,  $F(7, 232) = 16.94, p < .001, \eta_p^2 = .34$ , showing that RTs decreased with grade level. Figure 7 shows the pairwise Bonferroni post hoc analyses at the .05 level: The younger groups were not statistically different here (kindergarten to third grade), with adults and also fifth to sixth graders differing from them, and fourth graders lying in between.

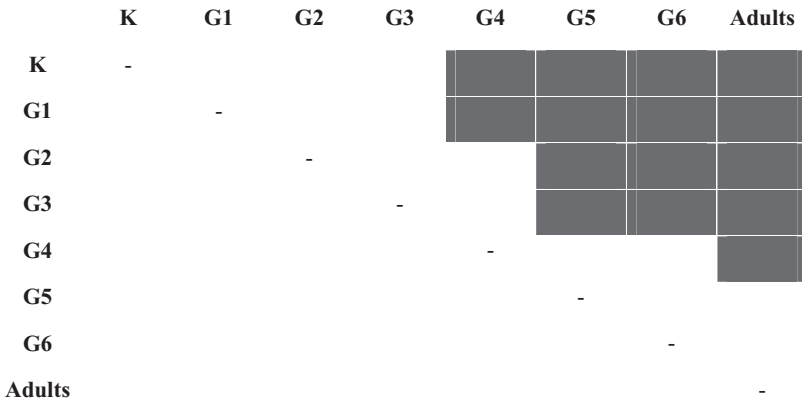
Noun gender was not significant in RTs to producing the plural noun phrase. Stem type of the plural noun was significant,  $F(1, 232) = 33.99, p < .001, \eta_p^2 = .13$ . As predicted, phrases containing nouns with nonchanging stems resulted in shorter RTs ( $M = 1,176.69$ ) than RTs to phrases containing nouns with changing stems ( $M = 1,388.63$ ). Likewise, noun suffix type was significant,  $F(1, 232) = 20.64, p < .001, \eta_p^2 = .08$ . As predicted, regular suffixes entailed shorter RTs ( $M = 1,221.12$ ) than irregular suffixes ( $M = 1,344.19$ ). Of all

**Table 4** Mean reaction times (in milliseconds) and standard deviations on the formation of the full noun phrase, by noun category (stem and suffix type) and grade

Noun category Grade	Regular Suffix Nonchanging Stem		Regular Suffix Changing Stem		Irregular Suffix Nonchanging Stem		Irregular Suffix Changing Stem	
	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.	Masc.	Fem.
Kinder-garten	1,196.2 (517.5)	1,316.4 (569.1)	2,597.0 (2,026.1)	1,925.6 (1,692.1)	1,804.6 (1,336.2)	1,695.6 (1,470.2)	1,998.9 (1,782.0)	2,348.9 (2,055.8)
First grade	1,366.6 (496.3)	1,379.6 (405.7)	1,673.2 (820.6)	1,611.2 (603.6)	1,486.1 (513.1)	1,446.0 (420.6)	1,736.5 (781.2)	2,000.4 (1,382.3)
Second grade	1,043.7 (272.1)	1,186.3 (330.9)	1,629.9 (1,074.4)	1,375.6 (1,044.3)	1,422.8 (899.7)	1,393.6 (706.2)	1,664.2 (497.31)	1,842.79 (623.4)
Third grade	1,079.7 (319.0)	1,501.9 (515.9)	1,494.2 (639.8)	1,323.6 (439.7)	1,432.7 (875.0)	1,346.7 (452.0)	1,671.5 (612.3)	1,476.03 (545.5)
Fourth grade	963.3 (278.8)	1,217.3 (565.1)	1,381.6 (997.9)	1,010.7 (254.5)	1,075.0 (604.5)	1,275.4 (782.4)	1,507.6 (1,174.4)	1,450.8 (991.2)
Fifth grade	1,032.9 (281.5)	1,032.7 (373.8)	1,018.7 (434.2)	903.0 (286.6)	947.1 (281.5)	997.1 (320.4)	1,062.5 (756.5)	949.1 (508.4)
Sixth grade	936.6 (413.8)	1,051.0 (351.9)	951.4 (502.3)	870.1 (263.0)	973.0 (515.4)	1,069.4 (411.4)	1,029.7 (608.9)	889.1 (292.7)
Adult students	727.1 (257.5)	790.2 (332.1)	848.4 (326.3)	640.1 (198.3)	721.5 (195.3)	755.7 (298.82)	766.2 (393.1)	787.5 (382.5)

*Note.* Masc. = masculine; Fem. = feminine.



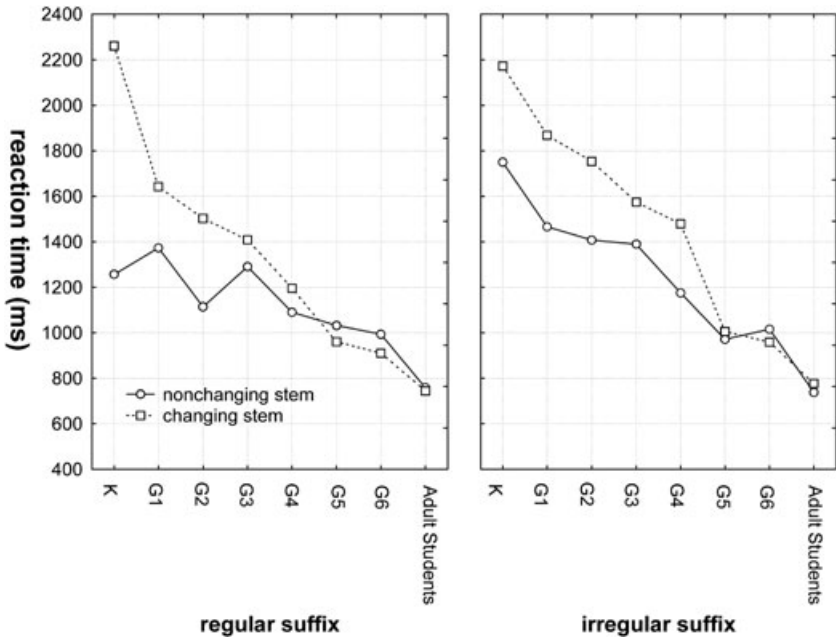


**Figure 7** Post hoc pairwise comparisons among grade levels in RTs to the plural noun phrase. Shaded cells indicate significant differences at the .05 level.

possible two-way interactions, only the Noun gender  $\times$  Stem type interaction was significant,  $F(1, 232) = 11.65, p < .002, \eta_p^2 = .05$ . Two three-way interactions emerged: Grade  $\times$  Stem type  $\times$  Suffix type,  $F(7, 232) = 2.56, p < .02, \eta_p^2 = .07$ , and Noun gender  $\times$  Stem type  $\times$  Suffix type,  $F(1, 232) = 10.75, p < .002, \eta_p^2 = .04$ . They are presented in Figures 8 and 9, respectively. The four-way interaction was not significant.

The Bonferroni analysis results of the Grade  $\times$  Stem type  $\times$  Suffix type interaction were as follows. Changing stems with regular suffixes converge with nonchanging stems by the third grade, whereas changing stems with irregular suffixes converge with nonchanging stems only by the fifth grade, 2 years later. Kindergarteners achieve the same RT to nonchanging stems with regular suffixes as do third and fourth graders to nonchanging stems with irregular suffixes.

The Bonferroni analysis results of the Noun gender  $\times$  Stem type  $\times$  Suffix type interaction were as follows. Regular feminines of both stem types take longer than do regular nonchanging masculines. Masculine changing stems do not show a difference between regular and irregular suffixes—both take longer than nonchanging stems—whereas irregular suffixes take longer than regular suffixes. Feminine stems show a different picture: Regular suffixes do not show a difference between stem types; however, irregular feminine suffixes show a similar difference between stem types, as do masculines.



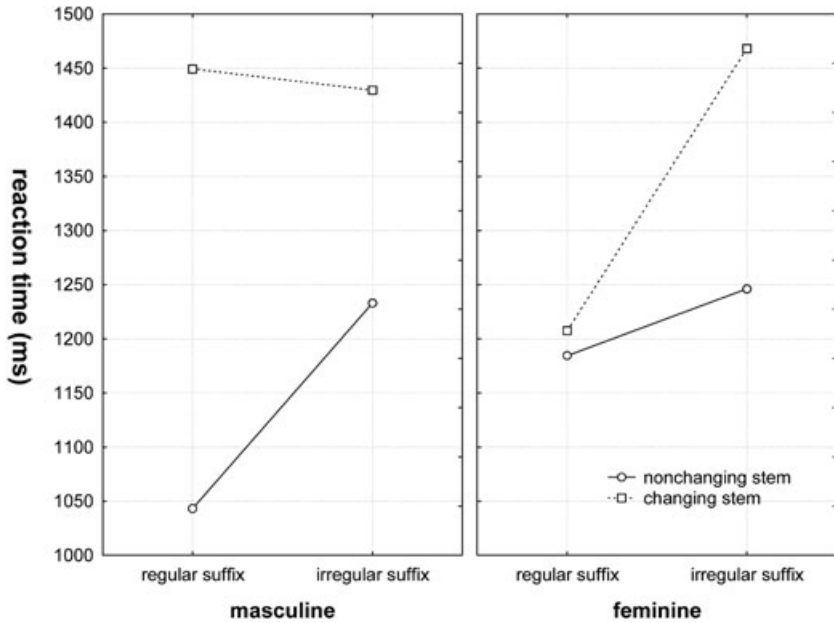
**Figure 8** Interaction between among level, stem type, and suffix type in RTs to the plural noun phrase.

**Discussion and Conclusion**

The study investigated the consolidation of Hebrew number/gender morphology in children and adolescents across the school years in comparison with adults, from three perspectives: marking plural suffixes on nouns, marking plural agreement on adjectives, and RT to pluralizing the noun phrase.

**Plural Nouns and Adjectives in Development**

In general, we found clear developmental trajectories for all three analyses: Children’s ability to pluralize nouns and adjectives increased markedly from kindergarten to adulthood, whereas RT to the plural phrase decreased concomitantly. The developmental process we found here shifts from a masculine-feminine dichotomy to the complex diversity of gender and form categorization. It involves the graded extraction of increasingly finer generalizations about Hebrew noun plurals from lexical experience—including gender marking, types of stems and stem changes, and conditions for irregular suffixation (Berman, 1985; Schwarzwald, 1982). To illustrate this path, take the example of



**Figure 9** Interaction among noun gender, stem type, and suffix type in RTs to the plural noun phrase.

monosyllabic masculine nouns shaped *CeC*, such as *ec* “tree,” *ken* “nest,” *cel* “shadow,” or *lev* “heart.” Young children, guided by learning mechanisms seeking transparency, regularity, and consistency, would tend to attach the masculine suffix to a nonchanged stem, yielding correct *ec-im* “trees” but incorrect *ken-im* “nests,” *cel-im* “shadows,” or *lev-im* “hearts.” Gaining morpholexical experience about the distributions of categories of Hebrew plurals from encounters with numerous singular and plural nouns will result in a set of different, and more specific, expectations regarding *CeC* nouns. They tend to change their vowels (thus, *ken/kin-im* “nest/nests”) or to reveal a “double” root (hence, *cel/clal-im* “shadow/shadows”); final voiced consonants tend to attract the irregular *-ot* on masculine nouns (hence, *lev/levav-ot* “heart/hearts”). The property that *CeC* nouns share with other plural categories—changing vowels in the stem and irregular suffix—will emerge first, whereas greater exposure to more monosyllabic nouns will result in doubling consonants (Avineri, 1976). Increased success on pluralizing nouns reflects emerging generalizations based on type and token frequency and consistency of plural forms.

Our findings also reflect the development of knowledge about adjective agreement. Whereas a linguist, or an educated adult, would be able to make the statement that adjectives always agree with the inherent gender of the noun, the path children are evidently taking does not assume such deep knowledge at first. Given the Hebrew frequencies described in the introduction, young children would learn a simple and superficial pattern of nonadjacent consistency: The adjective takes the same plural suffix as the noun: *N-im A-im* (e.g., *sir-im yaf-im* “pots pretty/Pl = pretty pots”) and *N-ot A-ot* (e.g., *sir-ot yaf-ot* “boats pretty/Pl = pretty boats”). Grammatical generalizations about gender/number agreement follow from such regular and consistent pairs. The shift from dichotomy to diversity is expressed in the gradual learning curve of those cases for which nonadjacent consistency is violated—in other words, when plural noun and adjective suffixes differ due to irregular suffixation, as in masculine *xalom-ot tov-im* “good dreams” or feminine *pnim-im tov-ot* “good pearls.”

Again, to explain how children learn about adjective agreement, we need not assume initial deep morphological knowledge. Learning will initially rely on experience with specific lexical items (i.e., adjective agreement with particular nouns; e.g., the fact that *kirot* “walls” always takes *A-im* agreement as in *kir-ot gvoh-im* “high walls”). Frequent encounters with N-A pairs in the input will then lead to the extraction of general statistical patterns relating to adjective agreement with nouns of both genders and, eventually, to the formation of abstract grammatical knowledge about obligatory N-A gender agreement. Lexical experience is critical in establishing a robust mental lexicon with strong singular-plural connections to be consulted in cases of irregular suffixation coupled with stem changes. For example, the singular, nonbound form *lev* of *levav-ot* “hearts” needs to be evoked to determine its masculine gender. The developmental increments in correct adjective agreement reflect both fine-grained morpholexical consolidation and the eventual forging of a procedural mode of accessing singular noun phonology to determine its inherent gender in noun-adjective agreement assignment. This interpretation is in line with recent crosslinguistic analyses demonstrating the interplay of phonological and distributional cues in gradually learning the grammatical roles of words rather than gaining abrupt access to a symbolic category (Monaghan et al., 2007).

Finally, RT decreased concomitantly with increased success on noun and adjective pluralization. In our case, the RT measured the time it took participants to reach a correct decision regarding the whole noun phrase. Our results demonstrate that with age and schooling, participants also took significantly shorter times to form correct plural phrases with cutoff points at the third, fourth, and fifth grades. RT is thus even more sensitive than morphological

accuracy in revealing the development of procedural morphological knowledge: Although accurate scores reach ceiling in some of the categories, the fact that learning is still going on and processing efficiency is increasing is evidenced by still decreasing RTs. This is especially apparent between sixth graders and adults who might give the same amount of correct responses, with adults having much shorter RTs.

### **Gaining Command of Complex Pluralization With Nouns and Adjectives**

Hebrew-speaking preschoolers are well versed in the morphological operations of attaching a plural suffix to a noun and copying it onto an adjective. Our results indicate that noun plurals with nonchanging stems and regular suffixes were at ceiling even in kindergarten, and corresponding adjective plurals were almost at ceiling. We attribute this high success rate to the frequency of regular plural inflections of nouns and adjectives in everyday and child-directed speech. The morphophonological change this operation requires is minimal, consisting of the attachment of a stressed suffix to the final consonant of a stem (e.g., *argáz* → *argazím* “crate/crates”), and is one that 3-year-olds are familiar with and 4-year-olds have already mastered (Ben-David & Berman, 2007; Ravid, 1995).

However, mastering more complex plurals is a long and arduous developmental process that requires learning to overcome both stem change and irregular suffixation. Two sets of parallel findings testify to the complicating roles of these separate facets of plurals: (a) the lower scores of stem-changed plural nouns and of adjectives agreeing with such nouns, plus the longer RT to forming plural phrases based on stem-changed nouns; and (b) the lower scores of nouns with irregular suffixes and adjectives in agreement with such nouns, plus the longer RT to producing phrases based on irregular nouns. Developmental results on noun plurals show that changing stems and irregular suffixes each constitute a separate difficulty for the younger groups, with mastery, in terms of achieving 90% correct scores, reached by the third and fourth grade. The most difficult category requires knowledge about both changed stems and irregular suffixes, with mastery reached only in the sixth grade.

The development of plural adjectives highlights the role of the two facets of noun irregularity. When noun suffixes are regular, adjective scores are very high from as early as kindergarten. The lower scores of agreement with irregular suffixes in the younger groups testify to children's extension of nonadjacent consistency to NPs with conflicting gender markers. When consistency is violated, learners have two possible sources for agreement assignment. The first is abstract generalizations that can be drawn from the input frequencies of specific conflicting plural N-A constructions, such as *kirot gvohim* “high walls,” and

of the general frequencies of conflicting *N-im A-ot* or *N-ot A-im* pairs. Both require experience with nouns in various syntactic environments.

A second strategy is determining inherent noun gender by retrieving the singular noun form and comparing it with the plural noun at hand. Whereas a nonchanged stem such as *xalom* “dream” would be easily comparable to its free singular form, a changed stem such as *dlay-im* “buckets” would be difficult to identify with the free singular *dli*, hence the lower scores in adjective agreement across the lower school grades and the longer latencies.

### Gender

As predicted and motivated in our review in this article, gender is a central organizing factor in the development of plural marking in Hebrew. In the first two analyses of plural nouns and adjective agreement, noun gender had a significant effect and interacted with the other variables; in the last analysis of RTs, it interacted with the other main variables. Across the board, feminine nouns were harder to process than masculine nouns. In general, plural feminine nouns and adjectives scored less than masculine nouns and adjectives.

In noun plurals, the interaction with other morphological factors shows the extent to which gender features in development. On the one hand, masculine stem changes are more numerous and diverse and take longer to learn, as indicated by the continued advantage of nonchanging over changing masculine stems up to adulthood, in contrast to the convergence of both stem types in feminine nouns by the third grade. On the other hand, feminine nonchanging stems take much longer to reach ceiling than masculine stems. In our view, this difference is due to the fact that masculine nonchanging stems are more transparent and processible than feminine nonchanging stems. In the former, the suffix is attached directly at the end of the stem, as in *agas/agas-im* “pear/pears,” whereas in the latter, the final *a* is always removed before suffix attachment, as in *xulca/xulc-ot* “shirt/shirts,” rendering the nonchanging stem in feminines more complex than in masculines. Thus, irregular feminines with both stem types start with lower scores in the younger groups and take longer to learn than irregular masculines, especially in nonchanging stems. We attribute this learning pattern to the fact that irregular feminines are less numerous, less structurally consistent, and less predictable than irregular masculines.

Noun gender affects adjective agreement too, albeit with lesser significance and with a smaller size effect than in plural nouns. First and foremost, this finding joins stem and suffix regularity in showing that noun morphology affects adjective agreement. Within nonchanging stems, correctly marking irregular plural feminines takes a staggering more than a decade longer than regular

feminines to develop. We attribute this dramatic finding to the fact that non-changing feminine stems such as *pnina* “pearl” omit their final *a* under plural inflection, making it difficult to determine that the irregular *pnin-im* “pearls” is based on a feminine stem. Whereas learning about agreement with changing stems of both genders takes most of the school years, agreement with irregular feminine nouns bearing changing stems is the most difficult category to learn due to its smaller size and lower degree of internal consistency and transparency.

Finally, whereas gender did not have a main effect on RT, interactions with the other morphological variables clearly indicate its important role in processing Hebrew agreement. In general, forming plural phrases with regular feminine nouns takes longer than with regular masculine nouns, due to the heavier processing burden of the former placed by skewed distributions, final vowel substitution, and pseudomasculine forms. In contrast, RTs to suffixation of changing masculine stems of both suffix regularities are equally long, attributed to the complexities of the masculine stem, whereas forming a phrase based on a changing feminine stem with regular suffixes is faster due to the smaller changes within the stem.

Our findings regarding pluralizing nouns and marking number/gender agreement on adjectives are best explained in an empiricist framework of a learning mechanism equipped with powerful data-mining abilities that increase with changing language experience across the school years. This is a gradual and uneven process starting with detection of general, often dichotomous patterns in the incoming data such as singular-plural or masculine-feminine marking. Eventually, children are shown to integrate different pieces of grammatical and morphophonological evidence to establish the complex and abstract categories that organize Hebrew number/gender marking in the nominal system. 1

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## Notes

- 1 The notion of “Dichotomy to divergence” in acquisition was proposed and developed by Ruth A. Berman (e.g., 2005, p. 110; 2008) in relation to the developmental shift from the sharply dichotomous distinction between narrative and expository genres in childhood to the more mature text production characterized by an intermixing of different orientations, attitudes, and specificity of reference. With Berman’s permission, we borrow and extend this terminology here to express the developmental shift from the dichotomous number/gender distinctions children rely on in pluralizing nouns and adjectives to the complex subregularities guiding adolescents’ and adults’ plural performance.

- 2 This refers only to nonroot  $-t$  spelled  $\mu$  (Ravid, 2005).
- 3 Pseudofeminine, as it actually ends with a pharyngeal consonant that is neutralized in Modern Hebrew speech (Ravid, 2005).
- 4 *CiCaCon* and *CiCCCon* are two variations of the same pattern. Speakers often use them interchangeably (e.g., *rishayon/rishyon* “license”).
- 5 The only two examples listed are *shibólet/shibolim* “wheat stalk/wheat stalks ” and *tolá’at/tola’im* “worm/worms.”
- 6 The unvoiced coronal affricate is marked by *c*.
- 7 Information retrieved February 5, 2010, from <http://www.safa-ivrit.org/>.
- 8 All of these are the result of the juncture of masculine pattern such as *miCCaC* and a root ending with a “deep” element such as the glottal stop? or the pharyngeal fricatives *h* or *’*. Thus, they are spelled with 9 or A , unlike feminine *a*, which is spelled with H.
- 9 A third agreement type in definiteness was not explored in this article.
- 10 As singular masculine forms are least phonologically marked, we take them as the default form and overtly mark only feminine gender and plural number.
- 11 Some Israeli researchers rely on frequencies from written newspaper reports, stories, and articles. These are problematic for the following reasons: (a) They do not reflect frequencies in children’s talk and in child-directed speech, but rather those of literate adults, and (b) these are nonvoweled words, thus effectively eliminating the variable of stem change, which has almost no representation in written nonvoweled Hebrew.

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## Appendix

### 32 Target Nouns (Singular/Plural Forms, Gloss in Singular)

Nonchanging stem, regular suffix, masculine

*pil/pil-im* “elephant,” *xatul/xatul-im* “cat,” *tik/tik-im* “bag,” *agas/agas-im* “pear”

Nonchanging stem, regular suffix, feminine

*xulca/xulc-ot* “shirt,” *matana/matan-ot* “present,” *smixa/smix-ot* “blanket,” *sira/sir-ot* “boat”

Nonchanging stem, irregular suffix, masculine

*kinor/kinor-ot* “violin,” *olam/olam-ot* “world,” *sulam/sulam-ot* “ladder,” *sadead-ot* “field”

Nonchanging stem, irregular suffix, feminine

*beyca/beyc-im* “egg,” *shana/shan-im* “year,” *pnina/pnin-im* “pearl,” *nemala/nemal-im* “ant”

Changing stem, regular suffix, masculine

*tof/tup-im* “drum,” *cel/clal-im* “shadow,” *dli/dlay-im* “bucket,” *shor/shvar-im* “bull”

Changing stem, regular suffix, feminine

*ta'ut/ta'uy-ot* “error,” *kalétet/kalat-ot* “cassette,” *dim'a/dma'-ot* “tear,” *misgèret/misgar-ot* “frame”

Changing stem, irregular suffix, masculine

*lev/levav-ot* “heart,” *kace/kcav-ot* “edge,” *iparon/efron-ot* “pencil,” *régesh/regash-ot* “feeling”

Changing stem, irregular suffix, feminine

*tola'at/tola'-im* “worm,” *dérex/drax-im* “way,” *ir/ar-im* “city,” *isha/nash-im* “woman”

#### **4 Target Adjectives (Masculine Singular/Plural/Feminine Plural)**

*tov/tovim/tovot* “good”; *gadol/gdolim/gdolat* “big”; *lavan/levanim/levanot* “white”; *shaket/shketim/shketot* “quiet”