Linguistic processing in Hebrew-speaking children from low and high SES backgrounds

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Abstract The aim of this study was to investigate the impact of Socio-Economic Status (SES) on Hebrew-speaking children's developing ability to pluralize nouns and mark adjectives in agreement with them. Participants were 180 gradeschool children from mid-high SES and 180 peers from low SES, in six consecutive grade levels. The task consisted of 32 singular noun-adjective pairs with nouns classified into four categories by suffix type (Regular and Irregular) and by stem type (Nonchanging and Changing). Results showed a consistent advantage to the high SES children in accuracy of noun and adjective plurals, with gaps widening when the morphological requirements were harder, that is, in the irregular categories. Moreover, the fact that low SES children's reaction times to producing the full plural phrase hardly decreased indicates that, unlike their high SES peers, they also did not gain more processing efficiency with age and schooling.

Introduction: SES, language and literacy

Since the groundbreaking work of Hart and Risely (1992, 1995, 2003), robust research evidence has pointed to a disadvantage in language and literacy skills of children from poorer, less educated, low SES backgrounds compared with children raised in more favorable circumstances (Bowey, 1995; Bradley & Corwyn, 2002; Gazmararian, Parker, & Baker, 1999). The current study provides evidence for a

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deficiency in linguistic skills in low-SES Hebrew-speaking gradeschool children. The notion of SES is taken here to be a multi-faceted phenomenon involving three major dimensions: family capital in the sense of financial and material resources; human capital in terms of education, schooling, and cultural resources; and social capital based on social networks supportive of career and professional advancement (Chiu & McBride-Chang, 2006).

Environmental factors such as parenting style, on the one hand, and nutrition, on the other, are known to impede the optimal command of linguistic proficiency and literacy-related abilities (Brooks-Gunn & Duncan, 1997; Lozoff, Jimenez, & Smith, 2006; Raviv, Kessenich, & Morrison, 2004). Amount and quality of linguistic input addressed to children have a connection with the SES background of mothers (Hoff, 2003; Rowe, 2008), with scarcer input resulting in a slower and less effective rate of language acquisition (Black, Peppé, & Gibbon, 2008; Ginsborg, 2006). These effects on language abilities emerge early on (Fish & Pinkerman, 2003) and are related both to the development of crucial brain regions (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009; Noble, Norman, & Farah, 2005) as well as to important cognitive functions (D'Angiulli, Herdman, Stapells, & Hertzman, 2008; Engel, Santos, & Gathercole, 2008; Farah et al., 2006; Fazio, 1997a, b). SES affects various domains, from sensitivity to the phonetic structure of spoken words (Blachman, Tangel, Ball, Black, & Mcgraw, 1999; Nittrouer, 1996), through lexical development (Arriaga, Fenson, Cronan, & Pethick, 1998; Qi, Kaiser, Milan, & Hancock, 2006) and narrative production (Price, Roberts, & Jackson, 2006) to acquisition of theory of mind (Cutting & Dunn, 1999; Shatz, Diesendruck, Martinez-Beck, & Akar, 2003).

Language abilities and emergent literacy in the preschool years are closely related to children's SES background (Foorman et al., 2006; D'Angiulli, Siegel, & Herzman, 2004). From infancy on, children from low SES backgrounds are exposed to largely directive instructions rather than to elaborative and enriching language (Ninio, 1980), they fail to receive appropriate linguistic and communicative mediation from their surroundings, they are less actively involved as conversational partners in family get-togethers, and they engage less than their more advantaged peers in joint book-reading and interactive writing with their parents (Anderson & Stokes, 1984; Aram & Biron, 2004; Teale, 1986). These practices are detrimental to their literacy skills (Aram, Korat, & Levin, 2006; Duke, 2000; McCarthey, 1997). Consequently, children from less economically established homes and with relatively less educated parents enter school with a disadvantage (Juel, Griffith & Gough, 1986; Natriello, McDill, & Pallas, 1990; Neuman & Celano, 2001).

The disadvantage is retained in school. Low SES children manifest relatively high rates of failure from the very lowest grades (Battin-Pearson et al., 2000), and their attainments remain consistently lower than average across the school years (Purcell-Gates & Dahl, 1991). They demonstrate poorer language skills in areas such as vocabulary and reading compared with their mainstream, middle-class peers (Au, 1998; Snow, Barnes, Chandler, Goodman, & Hemphill, 1991; Teale, 1986). Reading accuracy, reading comprehension, spelling and writing abilities are demonstrably weaker among children of low SES background (Chevrot, Nardy, & Barbu, 2011; Douglas, 2000). The limited experience of the low-SES population

with written texts, which is important for acquisition of textual features of written language (Berman, 2008) suggests literacy as an operative variable between them and higher SES groups (Fitzgerald, Spiegel, & Cunningham, 1991; Harste, Burke, & Woodward, 1994).

Similar findings have emerged from research in Israel (Aram & Levin, 2001; Davis, 1976; Feitelson & Goldstein, 1986; Ninio, 1980; Stahl, 1977), with preschoolers of low SES backgrounds having lower attainments in notions of print, phonological awareness, letter naming, writing, and identification of words (Aram, 2005; Korat & Levin, 2001). Schoolchildren of low and high SES backgrounds differed in a range of domains including text construction, figurative language, inflectional morphology, morpho-syntax, and lexical derivation (Berman & Ravid, 2010; Berman, Naydits, & Ravid, 2011; Ravid, 1995; Ravid, & Schiff, 2006; Schiff & Ravid 2004; Schiff & Lotem, 2011).

The current study focuses on pluralization of nouns and adjectives in Hebrew-speaking schoolchildren from two SES backgrounds. Inflectional morphology emerges early on in child language, but it has a long developmental route during the school years (Ravid & Schiff, 2011). Marking plural inflection on nouns and adjectives is a challenging task requiring lexical and morpho-phonological as well as grammatical insight, and is a well-known source of processing errors in usage. The acquisition of Hebrew plural adjective agreement in accordance with noun structure serves here as a window on the development of morphological knowledge and processing as a function of SES background.

Plural marking in Hebrew

Number marking is an example of inflectional morphology, which organizes linguistic information in language-specific conventionalized ways (Slobin, 2001). Plural marking on the categories of nouns and adjectives in Hebrew demonstrates two facets of inflection: Noun plurals illustrate *interpretable* inflectional features, which contribute to meaning in the sense of marking semantic information selected by the speaker/writer. Plural adjective agreement involves *uninterpretable* features, which automatically copy the information from the head of the syntactic unit without making an original contribution to meaning. The current study demonstrates the relevance of these features to learning to assign number marking to nouns and adjectives in Hebrew across development and SES background.

Noun plurals

Count nouns can be morphologically marked for pluralization, as in English *books* or *children*. Plural marking 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). As an inflectional system, plural marking is characterized by high token frequency, general and obligatory applicability (Bybee, 1985; Dressler, 1989), so that plurals are prominent in language usage,

"a constant presence" in both speech and writing. Semantically, plural inflection exhibits transparency, regularity, and predictability. These distributional and semantic aspects render plural marking highly salient for young children by facilitating the initial mapping of meaning or function onto inflectional segments. Accordingly, plural emerges as one of the earliest categories in child language development (Berman, 1981; Brown, 1973; Slobin, 1985). At the same time, plural systems (in Hebrew as in other languages) typically manifest morphological irregularities, which challenge early mastery. For example, some irregular English plurals are highly frequent, for example *men*, *women*, *teeth*, or *mice*, while others, such as *phenomena* or *crises* are rare and constitute part of the literate English lexicon. For children to gain command of such structural complexity, they have to construct coherent categories serving for both retrieval and combination of the relevant linguistic items. This involves a protracted developmental process that may continue across the school years (Laaha, Ravid, Korecky-Kröll, Laaha, & Dressler, 2006; Ravid & Schiff, 2009). The wide distribution, transparent semantics and opaque morpho-phonology have rendered noun plurals a testing ground for models of language acquisition and processing (Marcus et al., 1992; Ravid et al., 2008).

Hebrew noun plurals too demonstrate the semantics/structure dichotomy. Pluralizing Hebrew nouns is a linear process of stem suffixation, with plural suffixes incorporating information about number and gender. Plural formation is determined by two factors—(1) the inherent gender, and (2) the phonological marking of the singular noun. Singular masculine nouns end with a consonant—for example, *pil* 'elephant', or with a final stressed *–e*, as in *mixse* 'lid'.[1] Singular feminine nouns are phonologically marked by stressed *–a*, as in *pila* 'elephant,Fm', or by suffixes ending in *–t*,[2] such as *xanut* 'shop'. Regular plural suffixation takes into account both noun gender and phonology. Thus, masculine nouns take the plural suffix *–im*, as in *pil/pilim* 'elephant/s', while feminine nouns take the plural suffix *–ot*, as in *pila/pilot* 'elephant/s,Fm'. A recent analysis of Hebrew plurals (Ravid et al., 2008) indicated that most Modern Hebrew plurals in Child Directed Speech and children's peer talk is masculine, and this is corroborated by historical studies of Hebrew noun plurals (Tubul, 2003).

One complicating factor in pluralizing Hebrew nouns is irregular number/gender suffixation. Thus, some masculine nouns take the feminine suffix *–ot*, for example *sulam/sulamot* 'ladder/s' instead of the expected but incorrect *sulamim*. In the same way, some feminine nouns take masculine plural *–im*, as in *mila/milim* 'word/s', instead of the regular, and incorrect, *milot*. In some other cases, irregular suffixation results from a clash between noun gender and noun phonology, as in the case of *tsipor/tsiporim* 'bird/s' or *xatser/xatserot* 'courtyard/s'. Both these feminine nouns end with a consonant, like masculine nouns, however the former takes irregular masculine *–im* while the latter takes the regular feminine *–ot*. Such lexical exceptions and misleading phonology constitute stumbling blocks to young children

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[1] Stress is unmarked except in penultimate position, as final stress is default in Hebrew (Segall, Nir-Sagiv, Kishon-Rabin & Ravid, 2008).

[2] This refers only to non-root *–t* spelled ת (Ravid, 2005).

acquiring Hebrew pluralization (Berman, 1981; Ravid, 1995; Ravid & Schiff, 2011).

A second complicating factor is the fact that plural inflection may trigger stem change. Plural suffixation shifts noun stress to the final syllable created by the conjunction of the suffix and the final consonant of the stem, as in *tik/tikím* 'bag/s', *dégel/dgalím* 'flag/s'. Many stems in the Hebrew lexicon remain unchanged under suffixation, as in the cases of *rexov/rexovot* 'street/s'. However others undergo morpho-phonological stem changes such as vowel reduction, deletion, or change, stop/spirant alternation, and *t* omission. For example, singular *rakévet* 'train' drops the final *t* before attaching the plural suffix, to yield plural *rakavot*. In some cases, nouns may both change stem structure and take irregular suffixation. For example, masculine *iparon/efronot* 'pencil/s' has an irregular feminine suffix, and in addition, it demonstrates three stem changes: Vowel change ($i \rightarrow e$), vowel deletion ($a \rightarrow \emptyset$), and stop-spirant alternation ($p \rightarrow f$). Our prediction was that irregular suffixation and stem changes should hinder noun pluralization, especially in younger age groups (Ravid, 1995; Ravid & Schiff, 2009).

Plural marking on adjectives

A second plural category investigated in this study is marking Hebrew adjectives for plural agreement with nouns. In the current study, we focus on attributive adjectives in the noun phrase, which follow the head noun and agree with it in number and gender.[3] Taking the masculine singular form as the least marked, consider, for example, the following paradigm: *tik lavan* 'bag white', *smixa levana* 'blanket,Fm white,Fm', *tikim levanim* 'bags white,Pl', and *smixot levanot* 'blankets,Fm white,Pl, Fm'. Adjective plurals evidently constitute a secondary, purely structural category that does not require the involvement of a semantic component.

Even for straightforward cases of regular inflection as in the examples above, when the inherent grammatical gender of the noun matches its plural suffix, marking plural agreement on the adjective is not a simple task. It requires the simultaneous representation of two entities—the noun and the adjective, with the adjective plural suffix deriving from the gender of the head noun. Plural agreement is thus a procedure of scanning the plural noun phrase,[4] determining the gender of the head noun, taking note of the phonology of its plural suffix, and marking the adjective accordingly. For example, for masculine *sir* 'pot' and adjective *gadol* 'big', the plural NP 'big pots' would be *sirim gdolim* 'pots big,Pl', taking into account the masculine gender of the noun and the fact that it ends with a consonant; for feminine *sira* 'boat' the plural phrase would be *sirot gdolot* 'boats,Fm big,Pl,Fm', given the feminine gender of the noun and the fact that it ends with *a*.

The problem in marking plural adjective agreement resides in cases of clash between the plural noun suffix and its grammatical gender, where adjective agreement must follow inherent noun gender rather than its formal suffix phonology. For example, masculine *kir* 'wall' takes an irregular feminine plural

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[3] A third agreement category of definiteness was not investigated in this paper.

[4] Or the whole sentence, in cases of predicative adjectives.

suffix –*ot* to yield *kirot*, but despite this irregular suffix, the adjective would take its plural agreement from the inherent masculine gender of the noun *kir*. The plural phrase 'white walls' would then be *kirot gdolim* 'walls,Fm big,Pl,Masc', with conflicting suffixes on the noun and on the adjective.

The aim of this study was to investigate the impact of Hebrew noun morphology —suffix (ir)regularity and stem transparency or opacity—on the developing ability to create plural noun phrases on the basis of a singular NP as a function of age and schooling level, on the one hand, and SES background, on the other. This task requires syntactic, semantic and lexical knowledge, as well as the processing ability of accessing noun gender and making the appropriate application to adjective marking.

We had several predictions regarding plural marking in nouns and adjectives in these populations. Our previous studies on the development of noun plurals in first grade children (Ravid & Schiff, 2009, 2011; Schiff, Ravid, & Levy-Shimon, 2011) had indicated that noun plurals with regular suffixes and nonchanging stems might already have high success scores as early as in kindergarten. Therefore we predicted improvement with age and schooling on producing correct noun plurals with irregular suffixes and/or changing stems. From the morphological perspective, the hardest category should be nouns with changing stems and irregular suffixes. Regarding adjectives, we predicted that plural agreement should be paced by head noun morphology; that is, adjectives following nouns with changing stems and irregular suffixes should be harder to inflect correctly. Finally, we also predicted lower success and a slower rate of development in the low SES population, especially in the categories with irregular suffixes and changing stems.

Method

Participants

Study population consisted of 360 participants, half from mid-high SES and half from low SES. In each SES population there were six consecutive grade levels, with 30 participants at each grader level: 1st graders aged 6–7, 2nd graders aged 7–8, 3rd graders aged 8–9, 4th graders aged 9–10, 5th graders aged 10–11, and 6th graders aged 11–12. Each group contained an equal number of boys and girls. Participants were all native, monolingual speakers of Hebrew with no diagnosed hearing or visual impairment, learning or reading disability. All the participants had a normal academic development according to school records and had never been kept back a year.

Participants were recruited from two urban schools with strictly different SES populations. The Low SES school is located in a disadvantaged area in the center of Israel and takes in only children from the local neighborhood. The High SES school is located in one of the wealthy suburbs of Tel Aviv. The Ministry of Education SES Index ranks the High SES school as 3 and the low SES school as 6 on the Index (with higher numbers indicating a lower SES). According to the Poverty Report (2009), a comparison of the statistics for the two neighborhoods in which the two

schools were located provided the following: number of years of parental schooling (LSES, $M = 10.1$; HSES, $M = 16.7$), percentage of parents who work as professionals (LSES, $M = 3.8\%$; HSES, $M = 35.6\%$), average monthly per capita income (LSES, $M = 1,497$ NIS; HSES, $M = 3,138$ NIS), mean housing density, that is, average number of persons per room (LSES, $M = .92$; HSES, $M = 1.19$). Interview data with the school principals and the school guidance counselors yielded similar data.

Materials

Noun selection

The task consisted of 32 singular noun-adjective pairs, for example, *tof gadol* 'drum big = big drum', or *isha tova* 'woman good,Fm = good woman'. Nouns were classified into four categories by suffix type (Regular and Irregular) and by stem type (Nonchanging and Changing). Half of the nouns were masculine, and half feminine. Nouns were selected by the following process: 30 teachers were asked grade a list of 50 nouns taken from gradeschool texts on a five-point scale in terms of familiarity to gradeschool children. We discarded nouns considered by the teachers as completely unfamiliar and very familiar, and ended up with a list of nouns which had received the rank of 3–3.5 out of 5 on the scale. The full list of task nouns appears in the "Appendix".

Adjective selection

Only four adjectives were used in conjunction with the nouns—*gadol* 'big', *lavan* 'white', *tov* 'good', *shaket* 'quiet', all well-known, everyday adjectives familiar to children. Since Hebrew adjectives may also undergo stem change, we made sure that the target adjectives either had nonchanging stems (*tov/tovim* 'good/Pl') or else shared *a*-deletion, as demonstrated in the plural forms of *gadol/gdolot* 'big/Pl.Fm', *lavan/levanim* 'white/Pl', and *shaket/shketot* 'quiet/Pl,Fm'. This type of stem change is a very early acquisition in Hebrew-speaking children (Ravid, 1995; Ravid & Shlesinger, 2001). When tested on the task items, all of the participants from both SES backgrounds made the correct stem change on the three *a*-deleting adjectives.

Procedure

Participants were tested orally and individually in the spring (that is, 3 months before the end of the school year) in a quiet room at their school. Administration was computerized, as follows. Each participant was presented with a set of four training noun-adjective pairs, two masculine and two feminine, two with regular suffixes and two with irregular suffixes, two with nonchanging and two with changing stems. These pairs were presented in auditory form in singular and subsequently in plural form by the computer software, for example, *ner lavan* 'candle white', many *nerot levanim* 'candles white,Pl'. After training, the actual

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

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

experiment started. Participants heard 32 singular noun-adjective pairs as stimuli. Each stimulus singular NP was read aloud by the computer software, and the student was asked to say it aloud in plural form. For example, given the stimulus *olam gadol* 'world big = big world', participants were expected to say *olamot gdolim* 'worlds big,Pl = big worlds', that is, to pluralize the noun and to mark plural agreement on the adjective. Each response was audio-taped and transcribed by attending investigators (MA students majoring in Education). The computer software marked the onset of the participant's response. Presentation of the stimulus and the online recording of the responses were controlled by the SuperLab software program. Table 1 presents the structure of the Plural Noun-Adjective Task.

Scoring

Noun plurals were scored on correctness (accuracy) of stem and plural suffix. Adjectives were scored on accuracy of suffix, as related to noun stem and suffix. In addition, we measured reaction time to correctly producing the whole plural noun phrase. Only full responses were analyzed. All scores were converted to percentages.

Results

Noun plurals: accuracy

Table 2 presents correct responses on the four categories of noun plurals in the two SES populations and the six age groups.

We conducted a four-way ANOVA of Grade (6) × SES (2) × Stem type (2) × Suffix type (2) on the data in Table 2. All variables were found to be significant. Grade level was significant, $F(5,348) = 81.75$, $p < .001$, $\eta_p^2 = .54$, showing that correct performance increased with grade level. SES was also significant, $F(1,348) = 181.77$, $p < .001$, $\eta_p^2 = .34$: Children from high SES background scored higher ($M = 85.25\%$) than children from low SES ($M = 76.62\%$), as predicted. Stem Type was significant, $F(1,348) = 1,311.1$, $p < .001$, $\eta_p^2 = .79$: Nonchanging stems scored higher ($M = 88.63$) than changing stems ($M = 73.24$). Finally, Suffix Type was significant, $F(1,348) = 1,132.27$, $p < .001$, $\eta_p^2 = .77$: Regular suffixes scored higher ($M = 88.39$)

Table 2 Mean correct percentages and standard deviations on the formation of noun plurals, by noun category (stem and suffix type), population, and grade

Age group	No-change stem Regular suffix	Changing stem Regular suffix	No-change stem Irregular suffix	Changing stem Irregular suffix
1st grade HSES	99.58 (1.58)	81.04 (13.68)	66.25 (9.93)	53.96 (11.89)
1st grade LSES	96.46 (5.1)	70.63 (14.23)	62.92 (9.56)	44.58 (10.73)
2nd grade HSES	99.38 (1.9)	90.21 (10.85)	77.71 (12.14)	68.13 (12.32)
2nd grade LSES	96.25 (5.59)	81.87 (13.57)	68.54 (7.95)	53.96 (11.78)
3rd grade HSES	99.58 (1.58)	95.42 (7.67)	83.54 (10.31)	80.0 (13.77)
3rd grade LSES	99.17 (2.16)	83.96 (15.46)	73.13 (10.4)	55.0 (14.63)
4th grade HSES	100 (0)	94.17 (10.24)	84.17 (9.25)	83.54 (16.04)
4th grade LSES	99.17 (2.16)	88.54 (11.73)	74.58 (8.98)	58.33 (16.6)
5th grade HSES	99.58 (1.58)	96.04 (9.78)	90.63 (8.0)	86.67 (11.69)
5th grade LSES	98.13 (3.34)	92.29 (13.6)	80.63 (10.3)	67.29 (13.7)
6th grade HSES	99.79 (1.14)	96.46 (7.64)	94.58 (6.08)	93.54 (9.06)
6th grade LSES	99.58 (1.58)	93.13 (13.06)	83.75 (9.65)	78.13 (12.03)

than irregular suffixes ($M = 73.48$). Almost all two-way interactions were significant—Stem × Grade, $F(5,348) = 21.45$, $p < .001$, $\eta_p^2 = .24$, Stem × SES, $F(1,348) = 65.08$, $p < .001$, $\eta_p^2 = .16$, Suffix × Grade, $F(5,348) = 45.0$, $p < .001$, $\eta_p^2 = .39$, Suffix × SES, $F(1,348) = 120.02$, $p < .001$, $\eta_p^2 = .26$, and Stem × Suffix, $F(1,348) = 224.53$, $p < .001$, $\eta_p^2 = .39$. Importantly for our topic, the three three-way interactions involving SES were significant: and Stem × Grade × SES, $F(5,348) = 2.51$, $p < .04$, $\eta_p^2 = .04$, depicted in Fig. 1; Suffix × Grade × SES, $F(5,348) = 4.64$, $p < .001$, $\eta_p^2 = .06$, depicted in Fig. 2; and Stem × Suffix × SES $F(5,348) = 9.78$, $p < .003$, $\eta_p^2 = .03$, in Fig. 3.

Figure 1 shows that in noun plurals, Nonchanging stems increase gradually in high and low SES from under 85% to over 95% and from 80 to 90% respectively, with a steady 5% advantage for high SES participants. Changing stems start under 65% in high SES but rise steeply to merge with low SES Nonchanging stems at 90% in 6th graders, while in low SES they increase from 55% in 1st graders to 80% in 6th grade.
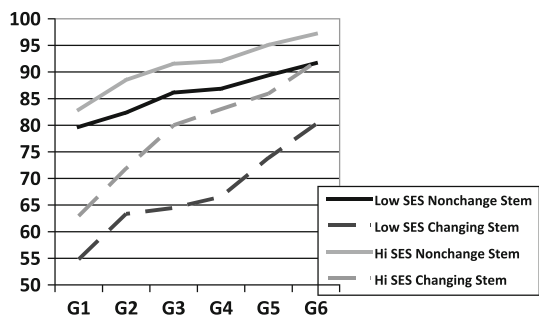
Fig. 1 Interaction of Grade, SES, and Stem in noun plurals

Fig. 2 Interaction of Grade, SES, and Suffix in noun plurals

Legend:
— Low SES Regular Suffix
- - Low SES Irregular Suffix
— Hi SES Regular Suffix
- - Hi SES Irregular Suffix

Legend:
— No change Stem Regular Suffix
— No change Stem Irregular Suffix
- - Changing Stem Regular Suffix
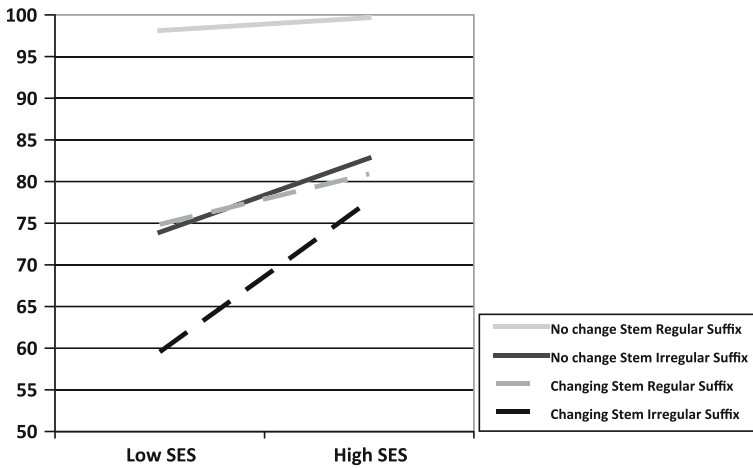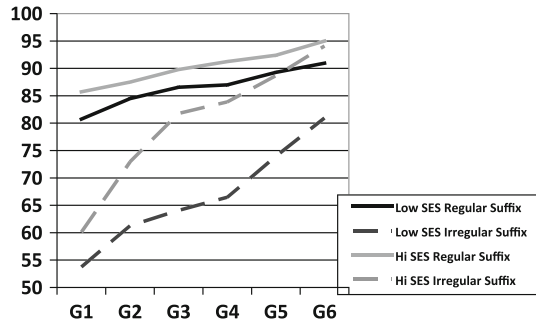- - Changing Stem Irregular Suffix

Fig. 3 Interaction of SES, Stem, and Suffix in noun plurals

Figure 2 shows that in noun plurals, Regular suffixes increase gradually in high SES from 85 to 95% and from 80 to 90% in low SES, with a steady 5% advantage for high SES participants. Irregular suffixes start at 60% in high SES but rise steeply to merge with hi SES Regular suffixes at 95% in 6th graders, while in low SES they increase from under 55% in 1st graders to 80% in 6th grade.

Figure 3 shows that in noun plurals, Nonchanging stems with Regular suffixes are at ceiling for both populations. Two intermediate categories are Nonchanging stems with Irregular suffixes and Changing stems with Regular suffixes, both at about 75% for low SES participants and over 80% in high SES participants. Finally, high SES participants have an advantage of over 15% in producing the hardest category—Changing stems with Irregular suffixes.
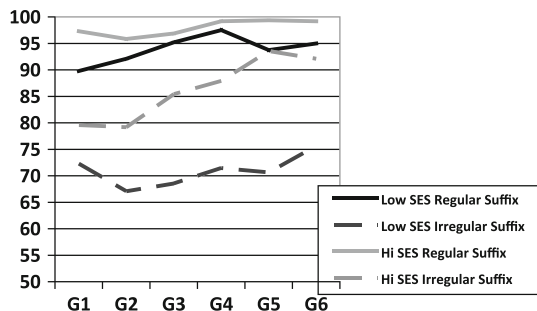
Adjective agreement: accuracy

Table 3 presents correct responses on adjective agreement with the four categories of noun plurals in the two SES populations and the six age groups.

Table 3 Mean correct percentages and standard deviations on the formation of adjective plurals, by noun category (stem and suffix type), population, and grade

Age group	No-change stem Regular suffix	Changing stem Regular suffix	No-change stem Irregular suffix	Changing stem Irregular suffix
1st grade HSES	98.33 (5.43)	96.25 (5.83)	84.58 (12.14)	74.58 (17.52)
1st grade LSES	90.42 (11.22)	89.17 (10.75)	78.75 (14.36)	65.83 (15.02)
2nd grade HSES	97.5 (6.05)	94.17 (11.24)	84.17 (13.1)	74.17 (15.37)
2nd grade LSES	92.08 (9.56)	92.08 (10.11)	72.5 (16.54)	61.67 (16.39)
3rd grade HSES	97.92 (5.76)	95.83 (7.58)	90.0 (10.58)	80.83 (13.83)
3rd grade LSES	96.67 (6.51)	93.75 (12.17)	75.0 (16.08)	62.08 (20.63)
4th grade HSES	99.58 (2.28)	98.75 (3.81)	91.67 (11.53)	84.17 (14.66)
4th grade LSES	97.08 (7.83)	97.92 (5.76)	76.67 (13.82)	66.25 (18.03)
5th grade HSES	99.58 (2.28)	99.17 (3.17)	94.17 (11.71)	92.92 (11.69)
5th grade LSES	95.0 (8.43)	92.5 (8.43)	74.58 (13.73)	66.67 (16.85)
6th grade HSES	99.58 (2.28)	98.75 (3.81)	93.75 (13.44)	90.42 (13.0)
6th grade LSES	99.83 (7.58)	94.17 (12.6)	80.42 (9.65)	70.83 (21.1)

We conducted a four-way ANOVA of Grade (6) x SES (2) x Stem type (2) x Suffix type (2) on the data in Table 3. All variables were found to be significant. Grade level was significant, $F(5,348) = 7.7, p < .001, \eta_p^2 = .1$, showing that correct performance increased with grade level. SES was also significant, $F(1,348) = 141.77, p < .001, \eta_p^2 = .29$: Children from high SES background scored higher ($M = 92.12$) than children from low SES ($M = 82.41$), as predicted. Stem Type was significant, $F(1,348) = 100.7, p < .001, \eta_p^2 = .22$: Nonchanging stems scored higher ($M = 89.83$) than changing stems ($M = 84.7$). Finally, Suffix Type was significant, $F(1,348) = 603.2, p < .001, \eta_p^2 = .63$: Regular suffixes scored higher ($M = 95.92$) than irregular suffixes ($M = 78.61$). Suffix interacted with Grade ($F(1,348) = 2.82, p < .02, \eta_p^2 = .04$) and SES, $F(5,348) = 64.1, p < .001, \eta_p^2 = .16$, and Stem interacted with Suffix, $F(1,348) = 61.16, p < .001, \eta_p^2 = .15$. There were two three-way interactions of Suffix x Grade x SES, $F(5,348) = 3.45, p < .006, \eta_p^2 = .05$, depicted in Fig. 4; and Stem x Suffix x SES, $F(1,348) = 5.02, p < .03, \eta_p^2 = .01$, depicted in Fig. 5.

Figure 4 shows that in plural adjective agreement, both high and low SES participants have close to ceiling scores in Regular suffixes, with some advantage

Fig. 4 Interaction of Grade, SES, and Suffix in plural adjective agreement
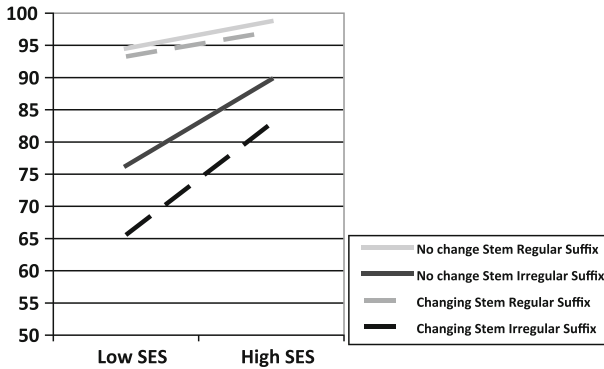
Fig. 5 Interaction of SES, Stem, and Suffix in plural adjective agreement

for the youngest and the oldest high SES groups. However high SES Irregular suffixes increase gradually from 80% in 1st grade to over 90% in 6th grade, whereas low SES Irregular suffixes show no change and remain in the 70–75% range throughout gradeschool.

Figure 5 shows that in plural adjective agreement, the two categories with Regular suffixes (both Nonchanging and Changing stems) are at ceiling for both populations. Nonchanging stems with Irregular suffixes are intermediate, showing a 15% advantage for high SES participants. Finally, high SES participants have an advantage of close to 20% in producing agreement in the hardest category—Changing stems with Irregular suffixes.

Reaction time

Table 4 presents RTs to correct responses on production of the full plural noun phrase by the four categories of noun plurals in the two SES populations and the six age groups.

We conducted a four-way ANOVA of Grade (6) x SES (2) x Stem type (2) x Suffix type (2) on the data in Table 4. All variables were found to be significant. Grade level was significant ($F(5,348) = 9.78$, $p < .001$, $\eta_p^2 = .12$), showing that correct performance took less time with increasing grade level. SES was also significant ($F(1,348) = 11.12$, $p < .002$, $\eta_p^2 = .03$): Children from high SES background took less time to produce a correct plural phrase ($M = 1,274.38$) than did children from low SES ($M = 1,427.85$), as predicted. Stem Type was significant, $F(1,348) = 32.72$, $p < .001$, $\eta_p^2 = .09$: Plural phrases based on nouns with nonchanging stems took less time to produce ($M = 1,287.69$) than did phrases with changing stems ($M = 1,414.54$). Suffix Type was also significant, $F(1,348) = 51.35$, $p < .001$, $\eta_p^2 = .13$: Plural phrases based on nouns with regular suffixes took less time to produce ($M = 1,276.21$) than did phrases with irregular suffixes ($M = 1,426.03$). Stem and Grade interacted, $F(5,348) = 4.53$, $p < .002$, $\eta_p^2 = .06$, and also Suffix and Grade, $F(5,348) = 2.64$, $p < .03$, $\eta_p^2 = .04$. Most important, the Stem x Grade x SES interaction was significant, $F(5,348) = 4.37$, $p < .002$, $\eta_p^2 = .06$, as shown in Fig. 6.

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

| Age group	No-change stem Regular suffix	Changing stem Regular suffix	No-change stem Irregular suffix	Changing stem Irregular suffix
1st grade HSES	1,373.11 (420.92)	1,642.25 (619.43)	1,466.09 (424.84)	1,868.45 (17.52)
1st grade LSES	1,365.13 (458.18)	1,527.21 (582.63)	1,606.08 (793.26)	1,786.27 (845.38)
2nd grade HSES	1,115.0 (251.76)	1,502.75 (713.62)	1,408.22 (576.87)	1,753.49 (435.77)
2nd grade LSES	1,235.79 (500.49)	1,516.17 (1,066.58)	1,773.31 (1,085.28)	1,898.32 (1,303.9)
3rd grade HSES	1,290.8 (335.35)	1,408.91 (437.39)	1,389.7 (539.8)	1,573.76 (474.82)
3rd grade LSES	1,340.36 (350.81)	1,429.48 (561.27)	1,454.95 (565.29)	1,762.62 (1,001.42)
4th grade HSES	1,090.28 (354.51)	1,196.16 (529.17)	1,175.2 (660.28)	1,479.2 (958.7)
4th grade LSES	1,285.22 (265.31)	1,392.89 (486.83)	1,374.98 (453.04)	1,827.4 (978.86)
5th grade HSES	1,032.79 (270.55)	960.82 (256.24)	972.11 (236.41)	1,005.81 (609.64)
5th grade LSES	1,272.99 (419.05)	1,134.82 (345.29)	1,275.07 (429.13)	1,255.78 (447.34)
6th grade HSES	993.82 (344.51)	910.75 (357.16)	1,016.21 (450.66)	959.43 (400.43)
6th grade LSES	1,274.87 (596.29)	1,336.61 (546.96)	1,322.5 (521.24)	1,609.35 (635.65)

Fig. 6 Interaction of Grade, SES, and Stem in reaction time to the full noun phrase
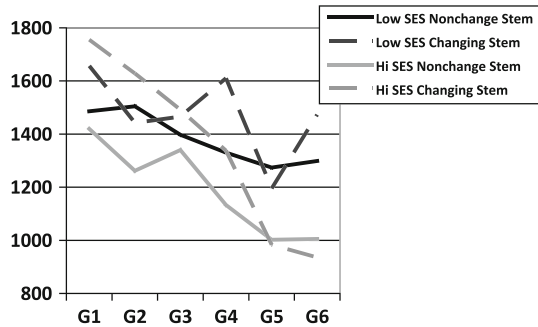
Figure 6 shows different developmental pictures for the high and low SES populations, respectively. In the high SES participants, RTs to Changing stems are about 200 ms slower than to Nonchanging stems in the two youngest grades, but for both stem types RTs decline steeply from 3rd grade and converge at 1,000 ms in 6th grade. In contrast, Low SES RTs almost show no decline. In Nonchanging stems they decrease slightly by 200 ms from 1st to 6th grade, while RTs to Changing stems stay virtually the same from 1st to 6th grade.

Discussion

This study compares the developing inflectional morphology abilities of Hebrew-speaking gradeschool children from two SES backgrounds in two related domains—(i) pluralizing nouns and (ii) marking adjectives in agreement with them. The most

important finding in this paper is the strong evidence for linguistic lacunae in Hebrew-speaking children growing up in deprived environments.

General developmental and morphological findings

The main findings on the development of noun and adjective pluralization as a function of stem and suffix type are as follows. First, in both nouns and adjectives, accuracy of plural form increased exponentially with age and schooling—reaching close to ceiling in all morphological categories in the high SES 6th graders; while at the same time reaction time to the whole plural phrase decreased, dropping to 900–1,000 ms in all morphological categories in the high SES 6th graders. These results demonstrate improvement not only in the ability to correctly assign morphological suffixation to nominals and to change their stems appropriately, but also clearly testify to the growing automaticity in processing such morphological tasks across school age. These findings point to the robust consolidation across the school years of both types of inflectional abilities in Hebrew-speaking children—interpretable noun pluralization and non-interpretable adjective agreement. The developmental findings of this paper support previous studies of morphological acquisition in Hebrew, a language with a rich inflectional and derivational morphology (Berman, 1978; Ravid, 2011; Schwarzwald, 2001). Of particular interest in this context are developments in noun plurals (Ravid & Schiff, 2009; Schiff, Ravid & Levy-Shimon, 2011) and in the syntactic, semantic, and derivational consolidation of the Hebrew adjective class (Ravid & Levie, 2010), which contextualize the findings of the current study. The fact that we find both an increase in correct noun pluralization as well as a decline in RTs to the whole plural phrase indicates that by the end of gradeschool Hebrew speaking children have a well-established nominal lexicon and the ability to relate items via their morphological construction.

However, not all types of morphological knowledge develop at the same time and the same pace. One difference was found between noun plurals, which showed a steep learning trajectory across gradeschool in cases of irregular suffix or stem change, and adjective plural agreement, which had a much shallower curve. We explain this difference in terms of the number-marking task which participants were asked to carry out. To correctly pluralize nouns, children have to acquire knowledge about the distributions of masculine/feminine gender and its marking on singular and plural nouns, and amass cues regarding the occurrence of irregular suffixes—such as the fact that irregular masculine nouns outnumber feminine nouns by far, or the tendency of masculine nouns ending with a voiced segment to take the feminine suffix (Ravid & Schiff, 2011; Ravid et al., 2008). Moreover, they have to gain command of a large enough lexicon with an adequate number of singular and plural nouns so as learn about different kinds of stem changes and how they relate to masculine and feminine nouns of particular morphological classes (Ravid, 1995; Ravid & Schiff, 2009). This multifaceted knowledge about irregularities in pluralization of nouns is not available to young gradeschool children, and our study demonstrates that it is acquired across the school years as children amass a larger

spoken and written lexicon and gain command of tools for processing words via morphology.

In contrast, marking adjectives in agreement with plural nouns seems to be an easier task of copying the grammatical information of gender and number encoded in the noun. As long as the singular noun is clearly marked for gender, extraction of the inherent grammatical information is possible even in cases where the noun takes an irregular suffix. To demonstrate this, consider masculine *sulamot* 'ladders' which takes an irregular feminine suffix, while retaining clear identification of the singular noun as masculine in gender. It is only when the shape of an irregular plural noun is distorted by stem change and is more difficult to relate to the singular noun that this task becomes harder (e.g., feminine *tolá'at* 'worm' with stem change and a masculine plural suffix *tola'im*). In this context recall that stem change hardly affected the adjectives themselves in our study, and that all participants made correct stem changes in the adjectives when required. Taken together, this explains why the path to correct plural agreement marking on adjectives is easier than pluralizing nouns.

A third measure examined reaction time to the whole plural phrase, showing a concomitant decrease with increased success on noun and adjective pluralization. Given that RT infers mechanisms underlying cognitive processing (Posner, 2005), this decrease indicates a shift from a more declarative form of operation to an increasingly automatized or procedural operation based on a coherently categorized mental lexicon, supporting a faster check of noun and adjective grammatical and phonological properties.

Morphological acquisition and processing in different SES backgrounds

Beyond these developmental and morphological analyses, the gist of our findings is the discrepancy revealed between participants of different socioeconomic backgrounds, which consistently points at a deficiency in morphological processing abilities in low SES children.

Noun plurals

The two SES populations showed clear developmental trajectories. The critical difference between them was highlighted in the interaction of SES with stem and suffix: There was no difference between SES populations in Nonchanging stems and Regular suffixes, but the two categories combining an easy and a difficult morphological component already showed a clear advantage for the high SES children. The most difficult category of Changing stems and Irregular suffixes (e.g., *lev/levavot* 'heart/s' or *ez/izim* 'goat/s') showed the largest gap between the two SES backgrounds.

Even more tellingly, the interactions of Grade and SES with stems and suffixes show to what extent morphological knowledge and processing is at a disadvantage in low SES children. First, there was a constant and consistent gap of about 10% between high and low SES children throughout gradeschool in Nonchanging stems

and in Regular suffixes, which did not close by 6th grade. For Changing stems and Irregular suffixes respectively, the picture was worse: a smaller gap at the beginning of gradeschool which widened towards its end. That is, the higher the requirement for morphological processing abilities, the larger the gaps between the populations.

Marking plural agreement on adjectives

The two SES populations showed completely different developmental paths in adjective pluralization. First, while the two populations differed negligibly on the two categories with Regular suffixes, great gaps were found between their performances on Irregular suffixes, especially in combination with a Changing stem, where low SES children showed a much lesser ability in accessing the singular noun and determining its gender in order to assign the correct plural suffix to the adjective. The developmental picture shows in fact that no learning was under way in the low SES population regarding the assignment of correct plural forms to adjectives with Irregular suffixes: while high SES children showed a steep increase in matching plural adjectives to nouns despite Irregular suffixes, the low SES children remained at the 70–75% level throughout gradeschool.

Reaction time

The picture is compounded by the comparison of the reaction times to producing the full noun phrase (plural noun and plural adjective) in the two populations. At the beginning of gradeschool, there were only small differences between categories and SES groups, but at its end, categories converged for each population and a considerable gap opened between them. Specifically, the two high SES lines dropped dramatically and converged by the end of gradeschool, whereas the low SES lines hardly showed any decrease in reaction time across gradeschool. This indicates that low SES children not only do not perform at the same level as their high SES peers on the morphological analysis of plural morphemes and the stems they attach to, they also do not gain more processing efficiency with age and schooling.

Our study did not involve a cognitive measure, which might raise the question of whether it was the SES or cognitive capabilities that was responsible for the poor performance of low SES children. However according to recent research, SES interacts with developing cognitive abilities in ways that are under intensive and extensive investigation (see review in Hackman & Farah, 2009). The literature indicates that children from low-SES backgrounds whose parents have a lower education level are consistently exposed to less spoken language and to less maternal expansion and extension of their utterances (Black et al., 2008; Ginsborg, 2006; Schiff & Korat, 2006). From as early as the first year of life, they are provided with less linguistic scaffolding and less explicit metalinguistic commentary on their spoken production (Hoff, 2003; Hoff & Tian, 2005; Raviv et al., 2004) in the domain of the lexicon, and may be due to less rich speech input. Given the crucial importance of linguistic input in language development (Gathercole & Hoff, 2007), it is clear that LSES children start off with a smaller inventory of lexical items and

grammatical options as well as a disadvantage at analyzing spoken language (Duncan, Brooks-Gunn, & Klebanov, 1994; Nittrouer, 1996; Ravid, 1995). This situation is exacerbated by a limited exposure to print and to written language and fewer opportunities for literacy activities (Aram, 2005; D'Angiulli, Siegel, & Maggi, 2004), with serious implications for academic achievements in school (Battin-Pearson et al., 2000; Campbell & Ramey, 1994; Chevrot et al., 2011; Schieffer & Busse, 2001; White & Kaufman, 1997). Moreover, a rich body of research now asserts that adverse environmental factors (Lupien, King, Meaney, & MCEwen, 2001) actually affect brain development (Raizada & Kishiyama, 2010), resulting in reduced (neuro)cognitive skills in low SES children, such as attention, memory, numerical development, and the ability to think about the mind of others (Engel et al., 2008; Farah et al., 2006; Lozoff et al., 2006; Noble, Wolmetz, Ochs, Farah, & McCandliss, 2006; Siegler, 2009; Stevens, Lauinger, & Neville, 2009). This means that impoverished linguistic input, coupled with problems in executive functions, impede low SES children's ability to represent and analyze words and syntactic units (Reynolds & Fish, 2010). We believe these factors underlie the discrepancy in morphological processing abilities between the two SES populations of our study.

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', *sade* / *sad-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', *misgéret* / *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* / *gdolot* 'big'; *lavan* / *levanim* / *levanot* 'white'; *shaket* / *shketim* / *shketot* 'quiet'

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