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ORIGINAL PAPER

Word-level morphology: A psycholinguistic perspective on linear formation in Hebrew nominals

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1 Introduction

Hebrew is a highly synthetic Semitic language, which is well-known for its non-linear root-and-pattern morphology. The current paper discusses a less familiar facet of Hebrew—linear operations relating stems and suffixes. It argues for their central role in Hebrew processing and acquisition, and proposes a systematic distinction between root-and-pattern and stem-and-suffix structures. The paper takes as its first theoretical departure point the usage—based lexicon-morphology model proposed and explicated by Bybee (1988, in press) whereby all lexical items are stored in memory and are related by highly reinforced representational patterns. According to this view, the organization of the mental lexicon emerges out of the repeated co-occurrence of morphemes and their consistent mapping onto specific meanings. Thus, morphology both expresses relationships among words and underlies their formation.

A second theoretical foundation concerns the impact of typological features on language development and processing. Recent cross-linguistic research has demonstrated the powerful impact of target-language typology on the process of acquisition from early preschool age in a range of domains, revealing that from very early on children are sensitive to the 'typological imperatives' of their language. That is, even very young children recognize 'where the action is at', so to speak, in the input language (Berman, 1986). Recently, Slobin (2001: 441–442) has developed the idea of *typological bootstrapping* in language acquisition, showing how competing forces in the history of each language brings about its particular typological character. Children exposed to input from a specific language develop in the natural course of language acquisition what Slobin calls 'explanatory systems' of their language system, which direct children inexorably towards

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typologically characteristic patterns of conceptual categorization and organization, lexicalization and grammaticization. The current paper investigates the organization of morphology with these two views in mind.

Hebrew morphology is rich in a number of senses which converge together. Firstly, from a semantic perspective, many grammatical and lexical notions are expressed in word-structure. Nouns and adjectives are obligatorily inflected for gender and number, verbs for gender, number, person and tense, prepositions for number, gender and person. In addition, Hebrew has synthetic optional bound morphology—genitive nouns and accusative verbs—side by side with their analytic, i.e., syntactic alternatives. Derivation is likewise semantically rich: nominal derivational affixes express agent, attributive, diminutive, instrument, location, collective and abstract dimensions, while verb patterns (or templates) express transitivity/agency relations such as inchoative, reflexive, causative, reciprocal and passive (Doron, 2003). Secondly, from a systems perspective, which is the focus of this paper, Hebrew has several different synthetic structural options for denoting these semantic dimensions, the two major ones being non-linear root and pattern affixation, and linear suffixation of stems. Finally, Hebrew morpho-phonological structure is varied and complex, with numerous allomorphs for stems, suffixes, roots, and patterns. For example, the free stem *bat* 'girl, daughter' also occurs as *bit-* in genitive nouns (e.g., *biti* 'my daughter'), *ban-* in plural form *banot*, and *bn-* as a bound stem in a compound (e.g., *bnot^ha-kita* 'girls^the-class = the class girls'). Morphological richness is a typological feature of Hebrew in Slobin's sense, which affects Hebrew speakers in discernible ways, as they rely on morphological cues from early on (Ravid & Gillis, 2002). The current paper focuses on the impact of a particular facet morphological richness — linear structures — on patterns of acquisition and processing in Hebrew.

The paper argues for a dual system of morphological formation and organization in Hebrew. In both inflection and derivation, word-internal structure consists of a head—a basic component which conveys the core lexical content of the word, and an affix—a categorial component which provides its classification (DiSciullo & Williams, 1987; Lieber, 1983). The lexical outcome is synergistic rather than cumulative, with the specific meaning of the word (whether inflected or derived) determined by various contextual factors (Aronoff, 1980; Elman, 2004). Two complementary Hebrew structures express this morphological organization in two different ways. In the typically Semitic non-linear root-and-pattern structure roots constitute the basic lexical component, and patterns—the categorial, classificatory component. Non-linear operations are discontinuous: For example, root *z-m-r* 'sing' serves as the core lexical component in *zimer* 'sing', *zamar* 'singer', and *zimra* 'singing', while verb pattern *Pi'el,* agentive pattern *Ca(C)CaC* and abstract *CiCCa* supply the classifying categories. A second, linear stem-and-suffix structure makes use of continuous morphemes: stems as the core lexical component of words, with suffixes as the categorial element. The words *itonim* 'newspapers' and *itonay* 'journalist' illustrate linear structure, with stem *iton* 'newspaper' as the head lexical component of the words categorized by plural suffix *-im* and agentive suffix *-ay*, respectively. These two construction types serve similar—though not identical—functions in the organization of the Hebrew mental lexicon, as shown below.

While this account in principle applies to all morphological classes in Hebrew (see discussion of linear operations on verbs in Schwarzwald, 2006), this paper focuses on the nominal class of nouns and adjectives, which share similar structural and

semantic features and use both non-linear and linear devices (Schwarzwald, 2002). Hebrew verb morphology is, in contrast, exclusively restricted to root-and-pattern structure, and moreover relies on a small set of seven verb patterns—while nominal morphology uses several dozens side by side with linear formation, blending, and compounding (Berman, 1987; Ravid, 1990; Schwarzwald, 1981, 2001a). The low type frequency and high token frequency of verb patterns, coupled with their crucial importance for clause construction, renders the Hebrew verb system an extremely early acquisition in comparison with nominal morphology (Berman, 1985; Ravid, 1995). For Hebrew nominals too, the Semitic 'highway' to word-formation—the non-linear option—is more basic from three points of view—structural, historical, and psycholinguistic, as enumerated below.

1.1 Systems

From a structural or systems perspective, root-and-pattern formation is the principal device for constructing words in Hebrew. It is designated in this paper 'morpheme-level morphology' since it brings together two sub-lexical components to form a word, and as such is confined to derivation in nominals.[1] As a consonantal, discontinuous entity, the Semitic root is not pronounceable, and as a sub-lexical bound morpheme, it has no lexical category. However, it conveys meaning and its radicals comprise a single structural entity—so that roots constitute the formal and semantic core of the morphological family they relate. For example, root *s-g-r* 'close, shut' underlies the morphological family in (1a–b):

(1a) **Verbs**: Active *sagar* 'close', passive *nisgar* 'be closed', causative *hisgir* 'extradite', reflexive *histager* 'shut oneself off';

(1b) **Nominals**
Adjectives: Passive resultatives *sagur* 'closed' and *mesugar* 'introvert';
Verb-derived: Nominals *sgira* 'closing', *hasgara* 'extradition', *sgirut* 'introvert-edness', *histagrut* 'self-closing', *séger* 'closure', *misgéret* 'framework', *sagir* 'coda'.

Roots thus constitute one organizational factor in the Hebrew lexicon by underlying clusters of words sharing the same basic lexical reference. Patterns constitute another by systematically grouping together words with the same categorial class and with the same derivational history, e.g., passive resultative adjectives such as *sagur* 'closed', all related to *binyan Qal—gamur* 'finished', *baduk* 'checked', *saduk* 'cracked', *banuy* 'built'.

Most Hebrew words are dependent on roots and patterns for their existence as lexical entities. All verbs, and many adjectives and nouns, are constructed of roots and patterns. Even those words which have no internal structure and are perceived as single morphemes or amalgams by Hebrew speakers such as *šafan* 'rabbit', *subsidiya* 'subsidy' or *cancel* spontaneously yield consonantal skeletons which are combined with patterns to yield new words. In this context, I argue against the view that non-linear Hebrew words are directly based on words (Bat-El, 1994): true, the skeletons extracted out of words to form new words always reflect their base words in structure and semantics, e.g., *hištafen* 'acted as coward' from *šafan* 'rabbit', *sibsed*

[1] Tense alternations in verbs are expressed through the root and pattern mechanism.

'subsidized' from *subsidiya* 'subsidy' or *kinsel* from *cancel*. In such cases, it is clear that the root serves as a direct mediator between two words—the base word and the new target word (Ravid, 1990). But these examples of words whose meaning is identical to that of a root include only newer words whose antecedents can be directly identified. In many of the morphological families related by roots this is not the case, and it is not immediately clear which single basic word would serve as the base form from which all others are derived via the root. For example, root *b-d-d* 'alone' may be derived from verb *boded* 'separate', adjective *boded* 'lonely', or adverb *badad* 'alone'; or consider *hexešix* 'darken (transitive and intransitive)', *huxšax* 'be darkened', *xašux* 'dark', *xóšex, xašexa* 'darkness', all linked through root *x-š-x* 'dark'—which is the base word from which the others are derived? Most probably, Biblical noun *xóšex* with the simple prosodic structure underlies verb *hexešix.* This is certainly the case in child language. This somewhat futile exercise is eliminated under the view that morphology not only creates new words but also expresses relationships among words—so that roots and patterns underlie the Hebrew lexicon alongside with words.

Linear structure is a less basic yet not marginal morphological device, and as will be discussed below, occupies an equally prominent though less visible position in Hebrew morphology. One difference between the two mechanisms is phonological: Non-linear morphology brings together two phonetically meager constituents which complement each other—consonantal roots and (mostly) vocalic patterns, to form syllable and word structure. In order to achieve phonological threshold, the root is obligatorily complemented by another sub-lexical discontinuous morpheme—the Semitic pattern, which supplies the prosodic template of the word and its internal vowels, often preceded and/or followed by pattern consonants, as in *niCCaC* (e.g., *nisgar* 'be closed') or *misgéret* 'framework'. As patterns provide potential prosodic structures, roots realize them, and together they specify the actual phonological structure of the word. In contrast, linear morphology is based on stems, which are fully fleshed out prosodic entities containing both consonants and vowels. Moreover, Hebrew stems are almost always words[2]—unlike English stems, which are often sub-lexical elements (e.g., *ident-ity, ident-ic-al, ident-ify*). Consider, for example, the following linear words in (2):

(2a)	Inflection: *tmun(a)-ot*	*sapar-it*,	*šulxan-enu*
	picture-PL	hairdresser-FM	table-GEN,1stPL
	pictures	hairdresser	our table
(2b)	Derivation: *tik-iya*	*medin(a)-ay*	*maxšev-on*
	file-PLACE	state-AGENT	computer-DIMINUTIVE
	filing cabinet	statesman	pocket calculator

Another difference is morpho-phonological. Roots and patterns are interwoven and fused into a single word, so that syllable structure is a function of the pattern template with the specific root consonants inserted into it. In contrast, words with linear

[2] Very few linearly formed nouns are not based on actual words, e.g. *rišmi* 'formal' and *recini* 'serious', both coined during the revival of Hebrew on the basis of Semitic words; this is also true of words such as *normali* 'normal' or *kolektivi* 'collective' which take foreign bases as their stems.

morphemes almost always re-syllabify by the adjunction of a suffix[3] to a stem, and constitute a linear string with clearer boundaries between the basic lexical component and the categorial element. The stem and the suffix are usually discrete, pronounceable and thus more transparent and concrete morphemes than root and pattern.

In the nominal domain, non-linear formation is restricted to derivation alone, and applies only once to form a word. In contrast, linear structure accommodates both nominal derivation and inflection and can have multiple applications by attaching a series of suffixes to increasingly longer stems:

(3) *enoš* 'human'
enoš-ut 'humanity'
enoš-i 'humane'
enoš-iy-ut 'humaneness'
enoš-iy-ut-a 'her humaneness'

As the examples show, linear formation takes as its base components words which may, in their turn, be constructed of a root and a pattern. For example, *saparut* 'hairdressing' is composed of stem *sapar* 'hairdresser' and abstract suffix *-ut.* In its turn, *sapar* is based on root *s-p-r* and agentive pattern *CaC(C)aC*. Hence its designation as 'word-level morphology', a secondary though robust device that operates on stems initially formed by non-linear derivation.

1.2 History

From a historical perspective, non-linear formation is again basic to Hebrew morphology while linear structure is a relatively latecomer (Bolozky, 1999). Both types of morphological structures are attested in Biblical Hebrew, the oldest Classical period of Hebrew. However, non-linear structures were more prevalent and expressed a variety of semantic notions, while linear formation was restricted in both semantic and structural terms. Hebrew structure became more analytic in post-Biblical periods, and linear formation expanded exponentially in the last millennium to include extremely productive suffixes such as abstract *-ut*, collective/location *-iya,* collective/diminutive *-on,* and denominal adjective *-i* (Bolozky & Schwarzwald, 1992; Shlesinger, 2000). In an examination of Hebrew dictionaries and texts, Schwarzwald (2001b) found that about half of the entries were constructed non-linearly from a root and a pattern, while linear derivation constituted under 15% of them. However, the composition of newly coined words was different — about one quarter were found to be non-linear and one quarter linear. This change not only enriched Modern Hebrew vocabulary by far and opened new vistas for expressing complex ideas—it has also provided the underpinnings for the formation of new lexical classes. For example, Classical Hebrew did not have a morphological class of adjectives and used noun and verb patterns for the expression of attributes (Gesenius, 1910). Today, *i*-suffixed denominal adjectives constitute a structurally

[3] According to one view, Hebrew has no 'true' linear prefixes—they are all borrowed prefixes (such as Modern *anti-, pro-* or Aramaic *du-* 'bi' or *tlat* 'triple') which bear no phonological relationship to the stem (Shlesinger, 1989, 2000). According to another, Hebrew does have true prefixes: *al-, beyn-, tox-, av-*, and many more. In fact, most of the original particles serve as prefixes, e.g. *al yad, al pney, kefi, le'at, karagil, uvxen, hayom* (Schwarzwald, 2002).

well-defined morphological class consisting of one third of all adjectives in written Hebrew (Ravid & Shlesinger, 1987; Schwarzwald, 2001a).

1.3 Psycholinguistics

Most of the evidence that I will review in the rest of this paper is psycholinguistic in nature, and will focus on empirical studies of processing and acquisition. The main thrust of this part will be to consider the existing evidence for the key role of non-linear formation in the organization of the Hebrew lexicon, and to present new evidence for the different yet important role of linear structures in nominal formation.

Semitic non-linear morphology has been the topic of a great deal of linguistic and psycholinguistic research (as summed up by most researchers in the field in Shimron, 2002). The literature indicates that both roots and patterns are prominent components of the Semitic lexicon and that they are both manipulated early on by young children in morphological structures. Hebrew-speaking children demonstrate an extremely early ability (as young as age two) to extract roots from words and make up new words with them (Berman, 2000; Clark and Berman, 1984). There is an abundance of evidence that the root has a central role in the organization of the Semitic lexicon (Abu-Rabia, 2002; Boudelaa and Marslen-Wilson, 2000; Ravid, 2002a, b), and occupies a separate level of representation in the mental lexicons of Hebrew and Arabic speakers (Berent & Shimron, 1997; Bolozky, 1999; Mimouni, Kehayia & Jarema, 1998). In a series of experimental studies of single word recognition and sentence reading, Frost and his collaborators have shown that Semitic roots are viable sub-lexical psycholinguistic entities (Frost, 2005; Frost, Forster, & Deutsch, 1997), and play an important role in reading and writing processes (see also Ravid, 2001). For example, Ravid and Bar-On (2005) found that written roots prime words sharing the same roots in gradeschoolers, and Ravid and Malenky (2001) showed that root perception is an early and pervasive ability in Hebrew speakers.

Patterns, like roots, have a major role in the organization of the Semitic lexicon. Therefore, as the root has been shown to occupy a separate level of representation, we may assume such separate status for the pattern. However, awareness of roots and patterns emerges at different age and schooling levels. Although very young children are easily able to extract roots from words and combine them with patterns (Berman, 1985; Ravid, 1995), developmental studies indicate that perception and explicit awareness of patterns emerge much later than root awareness, towards puberty (Ravid, 2002a, b; Ravid and Malenky, 2001; Ravid & Schiff, in press). This may be due to the fact that patterns are less perceptible than roots as they are mostly vocalic and the information they carry is grammatical and categorial rather than lexical. Processing studies of Semitic words in native-speaking adults have yielded conflicting results so far. Deutsch, Frost, and Forster (1998) and Deutsch and Frost (2002) report findings from Hebrew that verbal patterns prime words while nominal patterns do not, which may mean that verbal but not nominal patterns have psychological reality – so that verbs and nouns are organized and accessed differently in the mental lexicon. However, Boudelaa and Marslen-Wilson (2000) report findings indicating that the nominal pattern is used as a meaning-conveying unit during the processing of Modern Standard Arabic morphology.

Recent non-developmental studies also argue for the representation of linear structure, though it is restricted to plural formation. Berent, Pinker, and Shimron (1999) found that regular plural Hebrew suffixes are generalized to novel and idiosyncratic nouns as well as to borrowings and names. Berent, Pinker, and Shimron (2002) replicated these findings and found evidence for separate representation of stems and suffixes in the mental lexicon of Hebrew speakers.

The findings summarized come from a variety of researchers, with different views on the nature of representation. In the context of the current paper, the morphemes I discuss here — roots, patterns, stems, and suffixes — are regarded as *constructions* in the sense proposed by Goldberg (2003). Their representations are handled within a model in which all morphological relations are treated as lexical connections (Bybee & Newman, 1995), specifically within exemplar theory expanded to include all aspects of a linguistic sign, as presented and discussed in Bybee (in press). Under this model, these Hebrew morphemes are instances of constructions or word sequences that are stored in memory and accessed as units. Each token occurrence of a morpheme is categorized into a network and matched with its meaning or function, and this process strengthens the exemplar. The result is the emergence of constructions (e.g., roots), based on exemplar clusters which are similar phonetically and represent the same meaning.

1.3.1 Developmental evidence

The evidence regarding the rate of acquisition of non-linear versus linear structures is not entirely clear. On the outset it looks like the discrete linear structure should be more transparent and less abstract, and so easier to learn. In an experimental study, Clark and Berman (1984) showed that young Hebrew-speaking children first form linear agent and instrument nouns such as *agalan* 'wagoner' from *agala* 'cart' suffixed by agentive *-an*, and then go on to innovating non-linear ones. The explanation is that linear structures are discrete, and that stem (word) and suffix are more transparent and less abstract than root and pattern. This explanation is in line with the theory of natural morphology, proposed by Dressler (1985) and Wurzel (1998), which claims that agglutinating or linear morphology is more natural than stem changes (in this case—root and pattern structures), being more common in the world's languages and also within a single language, easier to process, earlier to be acquired in natural language development and later to be lost in aphasia. However Berman, in a later analysis of naturalistic data (2000), shows that spontaneous examples do not adhere to this format: Hebrew-speaking children innovate many more non-linear than linear nouns, preferring the typologically characteristic pattern of lexical organization.

Some more evidence for the salience of linear suffixes is provided by Ravid and Malenky (2001), where we found that children succeeded earlier and more on metalinguistic tasks requiring linear operations than those with non-linear operations (Fig. 1). However, note that in that study, linear structures were inflectional and non-linear structures were derivational—so that the semantic nature of the system rather than its form might have been the source of the difference.

In fact, other experimental studies provide evidence that Hebrew-speaking children are better able to discern roots than words as the core elements in words. In a longitudinal study of morphological awareness from kindergarten (age 5–6) to first grade

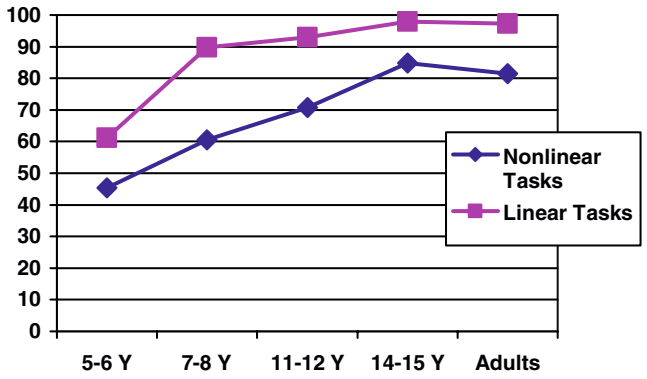

Fig. 1 Percentages of success on meta-morphological tasks in development (Ravid and Malenky, 2001)

(age 6–7), children were asked to say whether two words were related, e.g. non-linear structure: *ma'agal* 'circle'/*agol* 'round'; linear structure: *yad* 'hand'/*yadit* 'handle', and to motivate their statement (Seidman, 2000). Fig. 2 shows that first graders succeeded more on identifying root-related words than stem-related words, and that motivating root relations was easier than motivating stem relations even in kindergarten.

In the same study, children were asked to say whether two words with false (homophonic) structures were related — that is, words apparently related formally but not semantically. For example, words with non-linear structure: *šu'al* 'fox'/*ša'al* 'ask'; words with linear structure: *tsipor* 'bird'/*tsiporen* 'nail'. In kindergarten, children succeeded better on detecting that words had false root relations than that they had false stem relations. In first grade they succeeded equally on both structures. Thus, side by side with roots and patterns, Hebrew-speaking children also manipulate stems and suffixes in acquisition. And despite the higher opacity of non-linear structure it is as accessible to them as linear structure (Fig. 3).

In this context of evaluating the relative ease or difficulty of linear versus non-linear structures in Hebrew, note the artificial language learning experiment in Bybee and Newman (1995), which made it possible to distinguish the effects of stem change from those of type frequency. Bybee and Newman found no advantage for suffixes over stem changes involving interrupted phonological material such as English *sing/sang*. Rather, in the generalization phase, suffix regularity led to greater use of suffixes, and suffix irregularity resulted in more use of stem changes. This finding goes counter the natural morphology claim for a greater 'naturalness' of discrete linear suffixation, and also counter the claim that linear suffixes are more optimal psycholinguistically (1995: 653). The evidence in the specific case of Hebrew is that both structures are as 'natural' within the typology of Hebrew.

2 Linear formation in Modern Hebrew: a psycholinguistic perspective

Against this background, this section presents the psycholinguistic case for the role of linear morphology in the organization of the Hebrew nominal lexicon: A robust

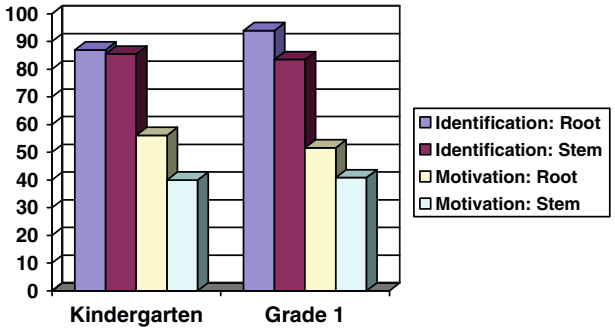

Fig. 2 Percentages of identification and motivation of root and stem relationships (Seidman, 2000)

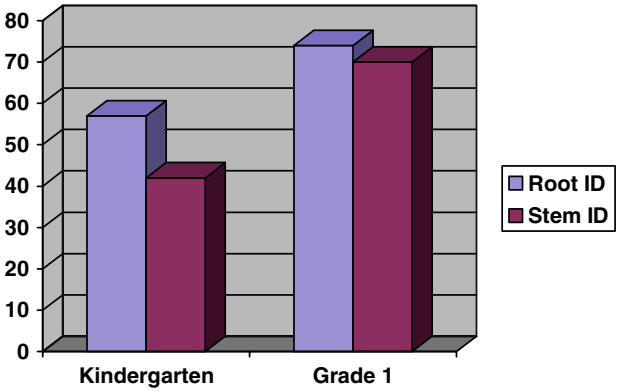

Fig. 3 Percentages of identification of false root and stem relationships (Seidman, 2000)

secondary system which expands the core vocabulary of Hebrew side by side with the more basic non-linear system. In this context, consider the richness of form and meaning/function in the linear system. This richness is important in a usage-based model of language processing and acquisition which attributes the emergence of representations to type and token frequency and salience of constructions (Bybee and Hopper, 2001; Tomasello, 2003). To start with, only linear suffixes express obligatory gender and number and optional genitive inflection[4] in nominals, as illustrated in (4) below:

(4a) **Obligatory morphology**

Gender: Masculine *-e mor-e* 'teacher' **Number:**
Feminine *-a mor-a* 'teacher' **Plural** Masculine *-im mor-im* 'teachers'
Feminine *-t xan-ut* 'shop' Feminine *-ot mor-ot* 'teachers'
sak-it 'bag' **Dual** *-áyim šnat-áyim* 'two years'
rak-évet 'train'

[4] Optional inflectional morphology (genitive nouns, accusative verbs, and so-called 'double' compounding) have got alternative syntactic forms, e.g., *simlata / ha-simla šela* 'dress-hers / the-dress hers = her dress'.

(4b) **Optional genitive morphology**

mor-o 'his teacher'	*mor-av* 'his teachers'
mor-at-o 'his teacher, FM'	*mor-ot-av* 'his teachers, FM'
xan-ut-o 'his shop'	*xan-uy-ot-av* 'his shops'

In addition, as shown by Bolozky (1999), all ontological meanings and classes conveyed by non-linear patterns also find expression in discrete suffixes. For example, suffixes *-ay* and *-an* serve the same agentive function as agentive patterns; and abstract suffix *-ut* parallels abstract patterns. Since every meaning expressed by non-linear nominal derivation can be expressed alternatively by the linear system, Hebrew employs two parallel systems for the same functions. In some cases, discrete suffixes and suffixes which constitute part of nominal patterns overlap. For example, agentive suffix *-an* (*madaán* 'scientist', from *mada* 'science') and agentive pattern *CaCCan* (*saxkan* 'player', root *s-x-k*) share the same functions; and the abstract suffix *-ut* (*boltut* 'salience' from *bolet* 'salient') also constitutes part of several action nominal patterns such as *hitCaCCut* (e.g., *hitragšut* 'excitement'). Another example is the case of *smixut*: One meaning is 'thickness' from *samix+ut*, the other is 'proximity' or 'construct state' from *s-m-x* + *CCiCut* (Schwarzwald, 2006). This greatly enhances the expressive strength of the Hebrew lexicon, with a range of forms expressing shades of meaning.

(5) *iton / iton-ay* 'journal / journalist' AGENT
roš / roš -an 'head / tadpole' AGENT
avir / avir-on 'air / airplane' INSTRUMENT
pa'ot / pa'ot-on 'toddler / nursery school' PLACE / COLLECTIVE
ma'afe / ma'af-iya 'baked item / bakery' PLACE / COLLECTIVE
kos / kos-it 'glass / wineglass' DIMINUTIVE
šone / šon-ut 'different / variance' ABSTRACT
iš / iš-i 'person / personal' AGENT-ATTRIBUTIVE (denominal adjective)
xatul / xatul-i 'cat / feline' AGENT-ATTRIBUTIVE (denominal adjective)

As a matter of fact, the linear system plays a more significant role in the Hebrew lexicon than constituting an alternative means of nominal expression to non-linear structure. Consider the fact that linear inflection is a source of lexical expansion. For example, Hebrew *šerutim* 'toilet', *bxirot* 'elections', and *kniyot* 'shopping' are formally plural inflections of *šerut* 'service', *bxira* 'choice, selection' and *kniya* 'purchase' respectively. This option is unavailable in the root and pattern system.

Moreover, linear formation is even semantically richer than non-linear patterns. Non-linear patterns, like noun-forming English suffixes (Bauer, 1983), denote two major meanings — agentive (including instrumental) and abstract. Agentive patterns include all of the participial *beynoni* verb forms (e.g., *Qal šofet* 'judge', *Hif'íl malxin* 'composer'), including those denoting passive resultative adjectives (e.g., *Pu'al mefursam* 'famous'), in addition to several strictly nominal patterns such as

CaC(C)aC (e.g., *tabax* 'cook') — which all serve for both agent and instrument nouns; and a number of patterns mainly dedicated to instrument (and not agent) meanings, such as *maCCeC* (e.g., *mavreg* 'screwdriver'). A second large class expressing abstractness includes a set of action nominals directly related to *binyan* verb patterns, such as *Hif'il haCCaCa* (e.g., *haklata* 'recording'), and an array of deverbal nominal patterns such as *miCCaC* (e.g., *mivxan* 'examination'). Several of these deverbal patterns also express place and collective meanings, but these seem to be secondary to the main abstract, deverbal meaning, as in *misgad* 'mosque'.

Linear suffixation carves out morphological space in a more fine-grained way. Parallel to the non-linear system, it has two agentive/instrumental suffixes, *-an* (as in *maclixan* 'winner') and *-ay* (*itonay* 'journalist'), with *-on, -it* more specifically expressing instrument meaning. But in addition, the linear system exhibits a richer semantic texture in a number of ways. It enhances the collective/place meaning that takes a backstage in the non-linear system in the two suffixes, *-on* and *-iya*, e.g., *pa'oton* 'nursery school', *cimxiya* 'flora'. The linear system specifies an additional semantic notion not given formal structure by nominal patterns[5]—the diminutive function expressed by the suffixes *-on, -it* (Hora, Ben-Zvi, Levie & Ravid, in press). It also clearly defines two lexical classes which would otherwise have no morphological characteristics: denominal adjectives (suffixed by *-i*, e.g., *dati* 'religious') and manner adverbs (derived from denominal adjectives by the suffix *-t*, as in *išit* 'personally').

Nominal meanings are mapped in more salient and transparent ways onto linear suffixes, both phonologically, because of their discrete character; but also because at least some of them exclusively denote semantic notions that are blurred in the non-linear system. For example, consider the case of the suffix *-ut* which uniquely derives abstract nouns from other lexical classes, e.g., *mahut* 'nature', *svirut* 'probability'; and attaches to stems with various internal structures, e.g., *adiv-ut* 'politeness', *kal-ut* 'ease (easi-ness)', and *nagar-ut* 'carpentr-y'.[6]. Semantically, it is a single form with a single meaning, catering to a well-known preference of children (Clark, 1993; Ravid, 1995). It also denotes non-specific abstractness, and thus has the advantage of generality over action nominals which require specific verb-related knowledge of *binyan* meanings.

As a result, the attachment of *-ut* to various stems serves as a platform for young children in learning to express abstract verb-related meaning by deverbal nominals. Children as young as age 3 spontaneously produce forms such as *simxut* 'joy' for adult *simxa,* or *cmi'ut* 'thirst' for adult *cima'on*. In a study of the acquisition of morphological nominalization in Hebrew (Ravid & Avidor, 1998), preschoolers and young schoolaged children produced (often ill-formed) stems suffixed by *-ut*, a situation defined in Berman (1994) as a state of *flux*. These included, for example, *havanut* for adult *havana* 'understanding' [Aviel, boy, 8;8]; *dxifut* for adult *dxifa* 'push/ing' [Hadas, girl, 8;8]; and *sanut* for adult *sin'a* 'hatred' [Inbar, girl, 5;6]; *ke'evut* for adult *ke'ev* 'pain' [Eden, girl, 5;7]. Children's suffixed stems indicated their awareness of the fact that it attaches to a wide array of formally different stems in Hebrewsuch as the fact that present-tense passive participles are commonly used in adult Hebrew as bases for *-ut* derivation (e.g., *Hif'il*-related *murkav-ut* 'complex-ity') by extending this structure to all present-tense participles, e.g., *mevin-ut*

[5] Except for the reduplicated template *CCaCCaC* (Bat-El, 2004).

[6] At the same time, *-ut* also serves on non-linear patterns, as discussed above.

'understand-ing' (for *havana*), *nivhal-ut* 'fright' (for *behala*) [Dor, 5;8]. They also patterned their responses after the two *-ut* suffixed action nominals *hiCaCCut* and *hitCaCCut*. Accordingly, children said *bilbel-ut* 'confused-ness' with past tense *Pi'el* as stem (for adult *bilbul* 'confusion'), [Hadas, girl, 8;8]; or *cam-ut* 'fast-ness', based on *Qal* past tense (for adult *com* 'fasting') [Shirit, girl, 11;3]. A third type of strategy was overmarking *-ut* on a root-and-pattern nominal, e.g., *ka'as-ut* 'anger-ness', cf. adult *ká'as* 'anger', given by several children; or *inyan-ut* 'interest-ness' for adult *inyan* 'interest' [Inbar, girl, 5;6; Meytal, girl, 11;9].

The discreteness and salience of *-ut*, which clearly and uniquely marks abstract concepts not readily accessible to children, can thus facilitate children's entry into morphological organization. I found an interesting spelling pattern in gradeschool children showing the representation of *-ut* as a discrete morpheme. In a spelling test of homophonous letters in Hebrew from first to sixth grade (Ravid, 2002a, b), almost no child out of 240 erred in writing *-ut* with rather than with , testifying to the robust status of as a function letter and children's perception of *-ut* as a function morpheme. Moreover, the only item which did not show improvement in spelling was *ec karut* 'felled tree', which started out with almost 100% correct spelling in first and second grade, but was increasingly written with in older age groups. This developmental pattern, which most probably would have ended up as a U-shaped curve if the test had been administered to older age groups, testified to an internal reorganization of morphological knowledge in gradeschool. To begin with, resultative *karut* 'felled' based on root *k-r-t* was interpreted as having the suffix *-ut*, hence the high success scores. As children's linguistic knowledge increased and became denser and more complex, at least some of them realized the root and pattern structure of *karut* in analogy to other adjectives of the same pattern (e.g., *kašur* 'tied up', *katuv* 'written'). This led to the spelling, which is attributed by young Hebrew spellers to root letters (Ravid, 2005).

At the same time learning to form linear words involves not only acquiring knowledge about categorial elements, i.e., suffixes, but also what actually happens to the core lexical component, that is to nominal stem structure, under suffixation.

2.1 Nominal stem structure in acquisition

While so much has been written and debated about the development of root and pattern perception in Hebrew and about the central role of non-linear structure in the Semitic lexicon, linear structure has been the topic of much less research. The following section shows how systematic and central stem changes[7] are in Hebrew morphology and to what extent they play an important role in morphological acquisition.

Almost all linear suffixation processes in Hebrew,[8] both inflectional and derivational, shift the stress to the newly created final syllable and very often result in re-syllabification of the word. For example, consider the inflected and derived nominals based on *ir* 'city' in (6), all with final stress:

[7] Please note that 'stem changes' in this context refer to stem allomorphy within Hebrew linear morphology, which is the consequence of suffixation; rather than to the stem changes of the *sing / sang / sung* referred to above in the debate regarding the 'naturalness' of suffixation vs. stem changes as single bearers of morphological operations.

[8] With two exceptions: segolate feminine forms ending in *—éCet / óCet* (e.g., *tinok / tinóket* 'baby / baby,FM'); and the non-productive locative noun formation (e.g., *tel-avíva* 'to Tel Aviv), which retains the stress pattern of the free stem.

(6) *ar-im* 'cities'
ir-a 'her city'
ir-oni 'urban'
ir-iya 'city council

Stress shift to the final syllable may leave the stem unchanged, as in the cases of *rexov/rexovot* 'street/s', *šir/širon* 'song / song collection'. In other cases it results in morpho-phonological changes to the noun stem already delineated in Tiberian Hebrew phonology (Baayen, 1985; Khan, 1997; Rendburg, 1997). Across the board, in inflection, derivation, and compounding,[9] Modern Hebrew nominal stems undergo roughly five types of stem changes as a result of suffixation and stress shift:

(7)
(i) *No change.*
(ii) *Vowel reduction or deletion*. Stress shift in nouns results in the deletion or reduction of vowels *a, e, o*[10](e.g., *pakid/pkidim* 'clerk/s' (Ravid & Shlesinger, 2001).
(iii) *Vowel change*. Certain nominal classes, such as monosyllabic nouns with 'double' roots, undergo vowel change when suffixed (e.g., *adom/adum-a* 'red/Fm, '*xec/xico* 'arrow/his arrow').
(iv) *Insertion or deletion of t*. Feminine nouns ending in *t* do not retain it when suffixed (e.g., *xanut/xanuyot* 'shop/s'). In other cases, a final *-t* is attached to feminine stems ending in *-a* (e.g., *šana/šnaton* 'year/cohort').
(v) *Stop/spirant alternation.* The Classical phonological process of spirantization has disintegrated in Modern Hebrew into stop/spirant alternation conditioned by a host of morpho-phonological and lexical contexts. It now involves both spirantization (e.g., *zikaron/zixron dvarim* 'memory/memorandum') and spirants changing into stops (e.g., *dov/dubon* 'bear/teddybear', *kaf/kapot* 'spoons').
(vi) *Full stem change*. In some cases, stems undergo more than one change or may transform completely (e.g., *kélev / kalba* 'dog / bitch', *séret / sirtiya* 'film / film library'; *iša / našim* 'woman / women'; *emet / amiti* 'truth / true').

Note, for example, how vowel deletion and t-insertion operate across the board in words inflected and derived from the same stems:

(8a) stem *safa* 'language / lip'
sfat-áyim 'lips' DUAL
sfat-on 'lipstick' INSTRUMENT
sfat-a 'her language' GENITIVE
sfat-i 'linguistic' DENOMINAL
sfat^maxšev 'computer language' COMPOUND HEAD

[9] Though stem changes in bound compound heads are restricted in Modern Hebrew (Ravid & Shlesinger, 2001)

[10] The vowel *a* deletes most frequently two syllables before the stress, whereas *e, o* delete in the penultimate position (Ravid & Shlesinger, 2001).

(8b) stem *šana* 'year'
šnat-áyim 'two years' DUAL
šnat-on 'cohort' COLLECTIVE
šnat-a 'her year' GENITIVE
šnat-i 'annual' DENOMINAL
šnat ha-kof 'year of the monkey' COMPOUND HEAD

These frequent, prevalent and comprehensive changes in stems are the point where linear and non-linear formations meet. In the classical traditions of Hebrew morphological analysis, morpho-phonological categories are classified by their patterns, sometimes by their meanings, and by the typical stem changes they undergo as part of the sweeping phonological generalizations that can be made about the nominal structure of Hebrew (Gesenius, 1910). Thus for example the segolate *CéCeC* class undergoes fairly predictable changes in morphological operations, illustrated in denominal *késef / kasp-i* 'money / financial' and plural *késef / ksaf-im* 'moneys'. And the same applies to the adjectival color category *CaCoC* which undergoes stem changes as in *cahov / cehub-im* 'yellow / Pl.' which are not typical of patterns with the same form but not the same meanings, e.g., *karov / krov-im* 'close / PL'. In the same way, two morpho-phonologically similar structures with different semantics behave differently: agentive stem *Ca(C)CaC* retains its vowel when suffixed (e.g., *sapar / sapar-it* 'hairdresser / FM'), while stems in non-agentive *CaCaC* undergo vowel deletion (*davar / dvar-im* 'thing / s').

Recent empirical studies testify to the centrality of stem changes in the acquisition of Hebrew morphology. Plural formation is the first and most extensive encounter of Hebrew-speaking children with this crucial phenomenon and serves as both a window on nominal operations and a testing ground of nominal morphological processes for children (Levin, Ravid, & Rapaport, 2001). Inflectional noun morphology emerges in Hebrew-speaking children very early on (sometimes as early as the second year of life) as evidenced by both naturalistic data (Berman, 1985; Levy, 1980; Ravid, 1995), and cross-sectional experimentation in Hebrew-speaking preschoolers (Berman, 1981; Ravid and Schiff, in press; Yagev, 2001). These studies indicate that toddlers prefer to follow Slobin's (1985) maxim of Formal Simplicy in retaining the original structure of nouns when inflecting them, e.g., juvenile *zaken / zakena* 'old man / old woman' (for correct *zkena*), *rax / raxa* 'soft, Fm.' (for correct *raka*), and *simla / simlot* 'dresses' (for correct *smalot*).

Converging evidence testifies to the centrality of stem changes in processes of language acquisition across childhood and adolescence. In a longitudinal study, Levin et al. (2001) found that noun genitives and denominal adjectives with substantial stem change (e.g., *késef / kaspo* 'money / his money', *késef / kaspi* 'money / financial') were more challenging for Hebrew-speaking kindergartners (aged 5–6) and first graders (aged 7–8) than stems with slight or no change (Figs. 4 and 5). In both categories, all stem types improved in the eight months between the two administrations of the task—but note that none reached 50% correct scores by first grade, since the maximum score was two. There was an interesting interaction between lexical class and stem type: Genitive nouns (an inflectional category) with substantial stem change were the hardest, while denominal adjectives (a semantically less predictable and transparent derivational category) also showed differences between non-changing and slightly changing stems. It

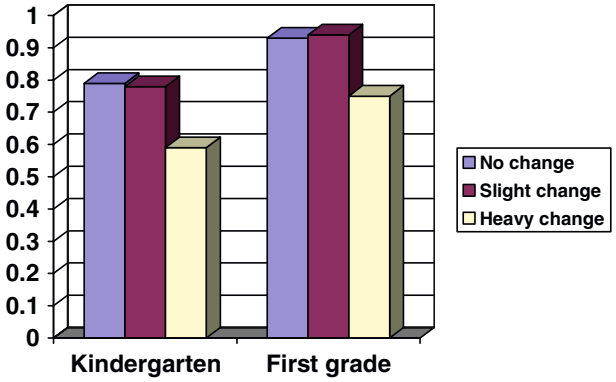

Fig. 4 Stem changes determine rate of acquisition in genitive noun inflection. Maximum score: 2. (Levin et al., 2001)

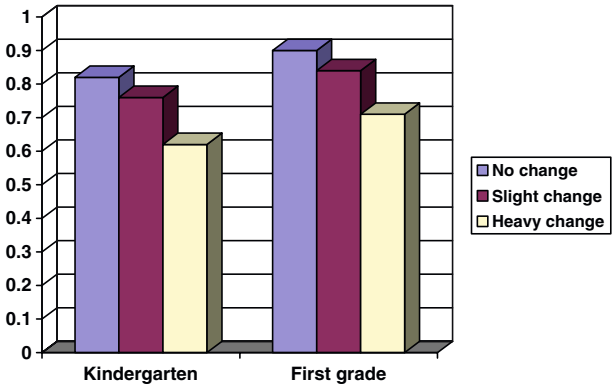

Fig. 5 Stem changes determine rate of acquisition in denominal adjective derivation. Maximum score: 2. (Levin, et al., 2001)

thus seems that the acquisition of stem changes has a long developmental history, and is determined—inter alia—by morpho-phonological, semantic and systemic considerations.

Moreover, types of stem change also determine the rate of correct acquisition of suffixes. Figure 6 shows that correct scores of suffixation in genitive nouns and denominal adjectives in the same study is determined by stem type, so that stems with more changes entail less success on their suffixes. Genitive suffixes are more difficult than denominal adjective suffixes since they denote a portmanteau complex of number, gender and person allomorphy (compare, for example, *ben/bno* 'son/his son' with *av/aviv* 'father / his father'). Denominal adjective suffixes consist of a single non-changing *-i* and, like all adjectives, are further suffixed in agreement with the head noun (e.g., *aviv / avivi / avivit* 'spring/springlike/springlike, FM'). Nevertheless both suffix classes are acquired in the same way, in tandem with stem change types. My interpretation of this finding is that it indicates that learning takes place based on

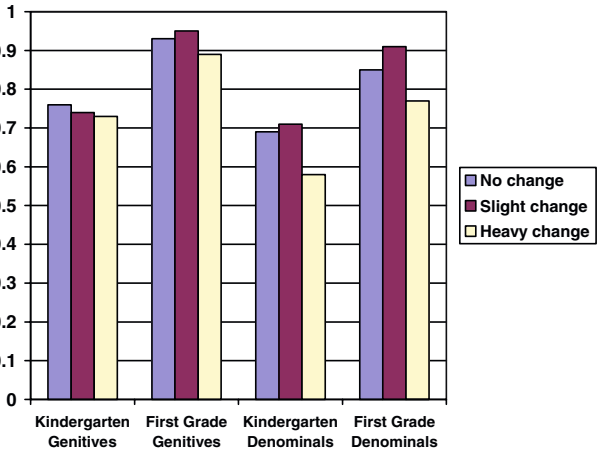

Fig. 6 Degree of stem changes determines rate of acquisition of suffix. Maximum score: 2. (Levin et al., 2001)

the repeated co-occurrence of stems and suffixes in specific words, from which generalizations are constructed.

Type and token frequency, consistency and transparency factor in learning and representing stem changes, even in cases of substantial stem changes. Ravid (1995) showed that preschoolers who were still making many stem-changing errors in other categories were already fairly accurate in inflecting nouns from the frequent and salient *CéCeC* class (e.g., *kélev* 'dog', *séret* 'movie') despite the total stem change involved. In contrast, pattern *CiCCa* with few (and mostly abstract) examples challenges children for a long time. For example, even eight year olds may err in pluralizing *dim'a* 'tear' into *dim'ot* instead of *dma'ot.* Token frequency also plays a role: The link between free and bound forms is learned early on and with few errors in frequently occurring bound lexical tokens such as *ben / banim* 'boy, son / s' or *bat / banot* 'girl, daughter / s', despite the stem change. The bound forms of frequent and semantically coherent items of the *CaCoC* color adjective class (e.g., *kaxol / kxula* 'blue/Fm') are early acquisitions, but rarer items such as *sagol* 'purple' and semantically inconsistent items such as *arox* 'long' take longer to learn (Ravid, 1995).

2.2 Linear structure in the development of literacy

The next studies show in what ways knowledge of stems and suffixes is paced not only by cognitive and linguistic development, but also by the acquisition of literacy. Figure 7 presents success on noun plural formation in good versus weak readers in second grade (mean age 6; 7). In both groups, irregular suffixes (unpredictable) do less well than regular (predictable) suffixes, and changing stems—less well than non-changing stems. However, not only are all categories lower in weak readers, the differences between regular and irregular stem and suffix types are much more pronounced. Figure 8 shows the results of a similar, though not identical, study on knowledge of noun plurals in children aged 4–6 (Yagev, 2001). In this case, the literacy criterion was related to SES (socio-economic status), which impacted on

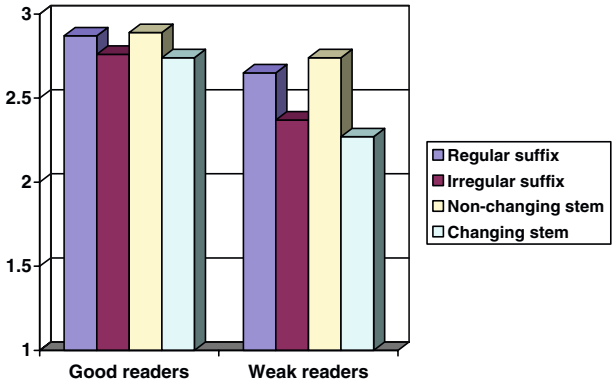

Fig. 7 Plural stem and suffix types in good and weak 2nd grade readers (Paz, 1999)

children's ability to acquire plural stems and suffixes. The two most diagnostic categories which clearly distinguished between the two SES groups were changing stems, and changing stems with irregular suffixes.

Finally, consider the evidence in Fig. 9 and 10, which compare the development of stem and suffix types in genitive nouns and plural nouns between two points of time (the beginning and end of first grade) in Hebrew-speaking children aged 6–7 (Schiff & Ravid, 2005). First, note that children made significant gains on all (non-ceiling) stem and suffix types in both categories. Second, non-changing stems, especially those with regular suffixes, were the easiest to inflect in both test categories. However, in noun plurals, an obligatory inflection, only changing stems improved between the beginning and end of first grade, while in noun genitives, an optional inflection, improvement took place across all stem and suffix types. Here, again, learning is paced by stem and suffix types and by their interface in different grammatical categories. We also found in the same study that changing stems of both categories (with all types of suffixes) and non-changing stems (with irregular or hard suffixes) were significantly correlated with phonological awareness, while

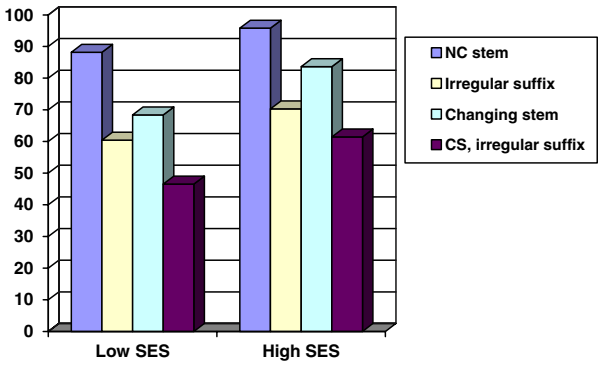

Fig. 8 Success on plural stem and suffix types in preschoolers aged 4–6 (Yagev, 2001)

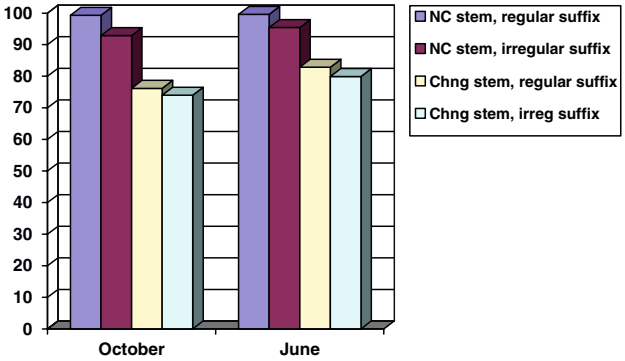

Fig. 9 Correct scores on plural stem and suffix types at the beginning and end of first grade (Schiff & Ravid, 2005)

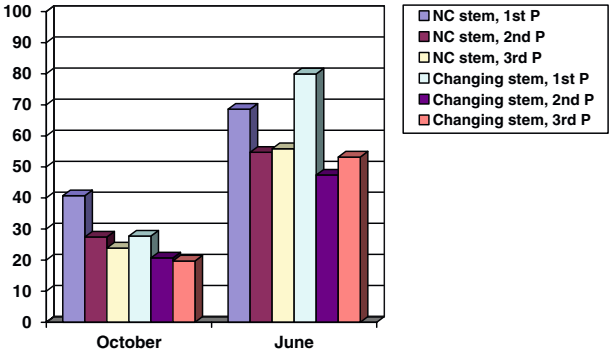

Fig. 10 Correct scores on genitive stem and suffix types at the beginning and end of first grade (Schiff & Ravid, 2005)

non-changing stems with regular suffixes were not. Thus the more complex the morpho-phonology, the tighter the relationship with verbal skills in development.

In what sense is learning about morphological structure and function related to literacy acquisition? The ability to analyze words into their morphological components is heavily reliant upon lexical development, a crucial component for academic achievement across the school years (Carlisle, 2000). During gradeschool and beyond, vocabulary knowledge increases exponentially side by side with growth in morphological skills (Anglin, 1993). Lexical and morphological development is fostered by the acquisition of written language and linguistic literacy in the school years (Ravid & Tolchinsky, 2002). Since the rich and varied morphological constructs of Hebrew are systematically and consistently reflected in its orthography and play an important part in linking written words, morphological strategies are extremely helpful in processes of reading and writing (Kaplan & Ravid, 2005; Levin et al., 2001). Learning about linear constructions is clearly part of these strategies.

3 Conclusions and implications

This paper set out to examine the role of linear morphology in psycholinguistic processes of Modern Hebrew. I have attempted to show that linear formation of words by stems and suffixes is essential morpho-phonological knowledge in Hebrew, no less prominent than the Classical Semitic non-linear formation. Knowledge about linear structures and their meanings underlies the ability to manipulate nominal stems across both inflection and derivation in Hebrew. This is systematic and generalizable knowledge that is diagnostic across populations and determines rate of acquisition in different populations and interacts with literacy processes.

What I hope to have shown is that Hebrew morphology operates productively in two different modes in nominal structures. One mode—morpheme-level non-linear affixation—mainly relates words through their roots and patterns, and is largely responsible for the core nominal lexicon of Hebrew consisting of shorter words.[11] A parallel, word-level linear mode uses extant words as core components for further multiple suffixation as in *civ'oniyut* 'colorfulness' based on *céva* 'color'. The linear mode is paradoxically a simpler and at the same time more complex morphological option. On the one hand, it constitutes an example of the more analytic, semantically and structurally transparent direction that Hebrew has been taking since its revival (Shlesinger, 2000) in providing a combinatorial device where retrieval of an opaque lexical item is blocked for some reason. Thus, I have recently heard adults use the innovative (and for me, ungrammatical) abstract nominals *ra'ut* 'badness' (from *ra* 'bad') and *ne'imut* 'pleasantness' (from *na'im* 'pleasant') where *róa* 'evil' and *nóam* 'amiability' were called for. This was on a talk show on the radio, and the speakers were (by their own description) uneducated native speakers of Hebrew. An even more extreme example was provided by an army sergeant in a very recent television program about Israel's withdrawal from Gaza. When talking about the disorderly way his soldiers were standing, he used (three times) the innovative (and completely unacceptable in my judgment) denominal adjective *hitpazruti*, which I understood to mean something like 'not properly aligned', based on the action nominal *hitpazrut* 'scattering' suffixed by adjectival *-i*. (I would have used resultative *mefuzar* 'scattered, unorderly' for the same situation). These two examples (together with the child data presented above) indicate that linear suffixes do have a separate representation in the mental lexicon of Hebrew, and that linear formation may offer an analytic option of expressing abstract states and attributes to less literate Hebrew speakers.

At the same time, linear formation is in some sense more complex than non-linear affixation because of its role in creating the 'advanced' lexicon of Hebrew (Ravid, 2004). It relies on a pool of basic words expanded by multiple suffixation (most often denominal adjective *-i* and abstract *-ut*) to form phonologically and orthographically longer words expressing abstract, complex and subtle shades of meanings (Bolozky & Schwarzwald, 1992; Nir-Sagiv, 2005). For example, as in *tiv'iyut* 'naturalness' derived from basic *téva* using denominal adjectival *-i* and abstract suffix *-ut*; or the recently coined *le'umatiyut* 'contrariness' from the lexicalized expression *le'umat* (*zot*) 'in contrast', again further expanded by the same

[11] Side by side with what Gesenius (1910) terms 'primitive nouns' and borrowed nouns.

suffixes. These are sophisticated words learned from exposure to the kind of language used in literate, specialized contexts—most often written language or the language of the media. Manipulating the linear lexicon in comprehension and production requires the platform of a large inventory of lexical items to serve for the analogical construction of structurally similar though semantically unique items. It also requires detailed and precise knowledge about stem types and the systematic ways in which they change under suffixation, and about the different categorial functions of linear suffixes.

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