

# Spelling root letters in school children from two SES backgrounds

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# Assumption: Spelling is lexical

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- ▶ Learning to spell is part of the acquisition of ‘lexical quality’ in a particular language (Perfetti, 2007)
- ▶ The more a person knows about a word in terms of its lexical semantics, phonology, morphology, and syntax, the more ‘qualitative’ its representation and retrieval
- ▶ A stable orthographic representation (= correct spelling) is an important signal of a word’s lexical quality
- ▶ Good spellers have qualitative lexical representations



# From speech to spelling

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- ▶ Children learning to spell words in their native tongue carry over the job of identifying systematic linguistic information from spoken into written language
- ▶ This involves two concurrent tasks
  - ▶ Identifying units and systematic patterns in the orthography,
  - ▶ Reciprocally mapping them onto relevant units and patterns in spoken language
  
- ▶ Ravid, 2012



# Statistical learning

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- ▶ To this end, young spellers need to keep track of multiple co-occurrences of different units
- ▶ Monitoring the frequencies, regularities and consistent behavior of phonemes, and morphemes in words
  - ▶ And how they are expressed in the specific orthographic patterns of their language



# Background on Hebrew

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- ▶ Hebrew-speaking spellers have to contend with a morpho-phonological system which, though originating millennia ago, still impacts on current processes of language acquisition, as well as **on the development of linguistic literacy**



# Aims: Round I

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- ▶ The focus of this study is **the interface of Hebrew phonology, morphology and orthography** with cognitive factors of developing abilities of pattern detection and generalization
- ▶ and linguistic factors of transparency, frequency, and prevalence



# Hebrew structure

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- ▶ Understanding how children learn to spell in Hebrew, a language with non-linear morphology, where discontinuous roots and patterns combine to form words
  - ▶ *limed* / *melamedet* / *talmid* ‘taught / teaching, Fm / pupil’ share root *l-m-d*, with pattern vowels interspersed between root radicals and function morphemes in the envelope
- ▶ Models of spelling representation (Dehaene et al., 2006) suggest that our brain is sensitive not only to adjacent but also to discontinuous letter combinations



# Phonology, morphology, and orthography

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- ▶ Spelling Hebrew involves knowledge in three main domains – **phonology, morphology, and orthography**
- ▶ Their mapping, however, is not transparent
- ▶ The history of Hebrew has left its marks in its current orthography in the form of **phonology-orthography mismatches**





# Phonology-orthography

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- ▶ While Hebrew phonology has undergone tremendous changes before and after its revival as Modern Israeli Hebrew, its orthographic system has come through the generations mostly unscathed
- ▶ Modern Hebrew orthography thus reflects defunct phonological distinctions due to the loss of the classes of emphatics, stop / spirant symmetry, gutturals/pharyngeals, and the historical glide *w*
- ▶ For example, the current Hebrew consonant *v* derives from two historical sources – the glide *w* (spelled ו), and the spirantized form of *b* (spelled ב, exactly like the stop *b*)



# The sources of spelling errors in Hebrew

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- ▶ Historical phonological distinctions are translated into the form of two distinct graphemes for a single phonemic segment
- ▶ Hebrew spellers are challenged by phonology / orthography mismatches
- ▶ *v* spelled by both ו and ם
- ▶ *k* spelled by both ק and כ
- ▶ *x* spelled by both ח and כ
- ▶ *t* by both ט and ץ
- ▶ In addition, the three letters ע ,ה ,א (historical guttural / pharyngeal) all stand for the glottal stop ʔ, often interchangeable with zero



# Morphology

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- ▶ Has a central role in mediating the grapho-phonemic interface in the lexicon
- ▶ Especially in languages with rich morphologies, such as Hebrew, where children early on identify the word-internal categories that signal lexical and grammatical information
- ▶ Morphological information is critical in learning to spell Hebrew



# Enter morphology

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- ▶ These same neutralized historical phonological distinctions are retained in Hebrew morphology
- ▶ The letters of each homophonous pair are constrained by their morphological roles as either root or affix (function) letters



# Reduction of complexity in homophonous affix/function letters

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- ▶ Only one of the two possible graphemes serves as a function letter

- ▶ *t*    *ʊ*    *т*

- ▶ *k*    *к*    *к̣*

- ▶ *x*    *х*    *п*

- ▶ The other grapheme does not serve as an affix letter

- ▶ Problem disappears

- ▶ Gillis & Ravid, 2006; Ravid, 2001, 2005, 2012



# Homophony in affix/function letters

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- ▶ Only 11 of the alphabet letters (out of 22) serve in function letters

▶ אני"י שלמ"ה כות"ב

- ▶ They stand for about 20 morphological roles
  - ▶ Both derivational and inflectional
- ▶ Low type frequency
- ▶ Very high token frequency



# Morphological role reduces complexity

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- ▶ Identifying the morphological role of the homophonous letter as an affix versus root letter should facilitate correct spelling



# Structure of the written Hebrew word

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- ▶ Morpho-orthographic structure indicates morphological role of graphemes

And-when-they, Fm-will-come

ולכשתבואנה

**Function  
letters**

**Root letters**



# Structure of the written Hebrew word

And-when-they, Fm-will-come

Tense/gender



# Morpho-orthographic structure

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▶ In-their-restaurants

Number / gender

Genitive person/number/gender

במסעדותיהם

Place

Pattern prefix

Function  
letters

Root letters



## Affix/function letters

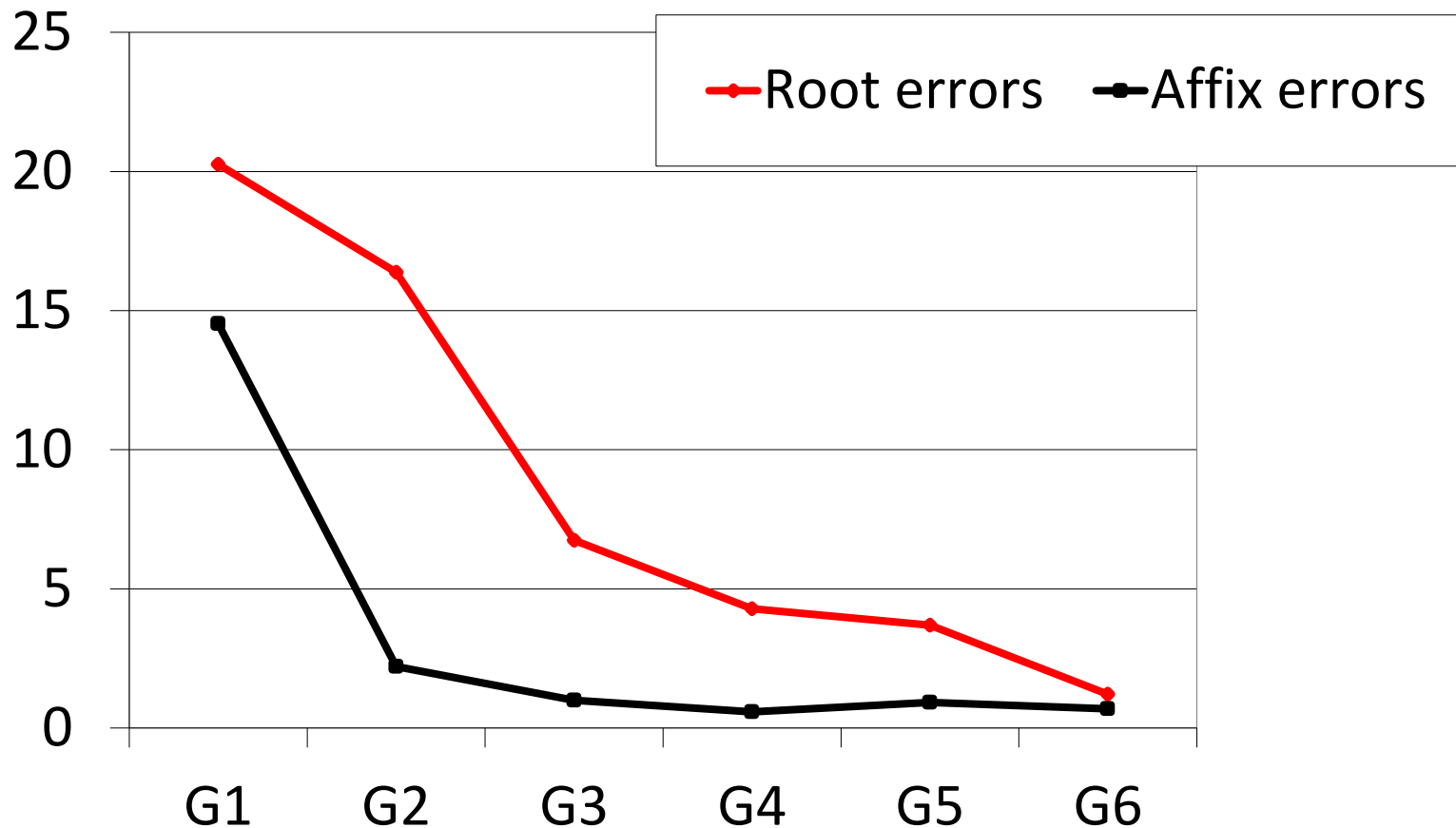
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- ▶ The small number of affixes (low type frequency), their ubiquity in spoken and written Hebrew (high token frequency), and their distinct peripheral positions all serve as reliable morphological pointers to affix morphology, and therefore to correct spelling
- ▶ We should thus expect the growth of morphological knowledge coupled with cognitive, linguistic and literacy development to override spelling homophony in native-speaking Hebrew spellers (Ravid, 2012)



# Ravid, 2001, 2005, 2012

See new function letter study by Schiff & Ravid [poster, this conference]



## Aims: Round II

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- ▶ Examining the developmental route of root letter spelling
- ▶ What are the factors affecting the learning of homophonous root letters?
- ▶ Challenges exacerbated in the context of different socio-economic (SES) backgrounds, known to impact linguistic and academic development (Golinkoff et al., 2018)



# Written roots

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- ▶ The morpho-orthographic structure of Hebrew words, which places constraints on vowel writing
  - ▶ *No representation of a and e in word internal positions*
  - ▶ *Restricted representation of i, o, u in word internal positions*
  - ▶ Ravid, 2012
- ▶ Root letters cluster in the center of the word, and affix letters precede or follow them in the ‘envelope’ of the word
- ▶ For example, in *melamdim* ‘they teach’, spelled מלמדים, the center of the word (bolded) contains the root letters, while the preceding ם and following ם׳ stand for the pattern and the plural morpheme, respectively



# Spelling homophonous roots

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- ▶ Unlike affixes, homophonous root letters constitute a major spelling challenge in Hebrew (Ravid, 2012), given about 1,500 different roots with the Zipfian frequency typical of lexical elements
- ▶ Root spelling is conditioned by a complex set of characteristics including root radical position, letter frequency, and morpho-phonological considerations.



# Spelling homophony in Hebrew

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▶ *satam*                      hate שטם      close סתם ▶

▶ *kara*                      mine כרה      read קרא ▶

▶ *maxar*                      tomorrow מחר      sell מכר ▶

▶ *navat*                      navigator נוט      take root נבט ▶





# In case of root homophony

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▶ *mevater*

- ▶ giving up    root *y-t-r* (spelling: יו)
- ▶ Carving    root *b-t-r* (spelling: ב)

מִוֹתֵר ▶

מִבֵּתֵר ▶

- ▶ No reduction of complexity by morphology



# Homophony in root letters

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- ▶ All 22 of the alphabet letters serve as root letters
  - ▶ They have just one role
  - ▶ Each root letter participates in the tri-consonantal root morpheme
    - ▶ 3 root positions
  - ▶ So needs to be learned in sequence with the others
- ▶ High type frequency
  - ▶ About 1,200 roots at the core of Hebrew
- ▶ Low token frequency
  - ▶ ‘non-saturated’



# Learning root letter spelling

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- ▶ Spelling root morphemes implies knowledge of Hebrew lexicon
  - ▶ All verbs, most adjectives and nouns are root-based
- ▶ Type and token frequency of root, of specific words, close / distant semantic relationship between words of the same morphological family
- ▶ Part of “lexical quality” in Hebrew





# Pointers to root spelling

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▶ Stop / spirant alternation in *b / v*, *k / x*

▶ *mevater*

▶ giving up                      root *y-t-r* (spelling: ו)    מוּתַר

▶ Carving                        root *b-t-r* (spelling: ב)    מְבַתַּר

▶ *v* always stays a spirant    *viter* ‘gave up’

▶ *ב* alternates between stop and spirant                      *biter* ‘carved’



# Root / word site

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- ▶ Pointers are mediated by a complex relationship between root radical site and position in the written word
  - ▶ Initial root letters tend to stand for stops
  - ▶ Final root letters tend to stand for spirants
  - ▶ Vowel lowering type is conditioned by root radical site
  - ▶ But root site is not the same as position in the word



# The study: Participants

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- ▶ A judgment study of the spelling of homophonous Hebrew root letters
- ▶ In 703 native speaking, typically developing participants in 11 grade levels
- ▶ Grades 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
  - ▶ Covering the entire school years spectrum
- ▶ Two SES backgrounds
  - ▶ 337 students from high-SES
  - ▶ 366 students from low-SES



# The study: Method

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- ▶ 88 sentences with **target words containing roots with homophonous letters**
- ▶ All five sets of homophonous root letters represented
- ▶ Each homophonous letter represented in the three root radical sites
- ▶ Initial      חשב      think
- ▶ Medial      סחב      carry
- ▶ Final      מרח      smear





# Consonantal root homophony

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▶ <i>t</i>	ט	ת ▶
▶ <i>x</i>	כ	ח ▶
▶ <i>k</i>	כ	ק ▶
▶ <i>v</i>	ו	ב ▶
▶ <i>s</i>	ס	ש ▶

phonemes

graphemes



# Procedure and test materials

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- ▶ Test carried out in the class forum
- ▶ Participants **heard** each of the 88 sentences with the target word containing the root with a homophonous letter
- ▶ *We caught the mouse in the **trap***
  - ▶ תפסנו את העכבר במלכודת
- ▶ Participants had to choose the correct spelling out of two written options

מלקודת / מלכודת



# Hypotheses

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- ▶ Spelling root letters will improve with age and schooling
- ▶ SES background will affect performance
- ▶ Older students will make more efficient use of morpho-phonological pointers, root and word structure



# Socio-economic Status (SES)

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Berliner, 2005; Chiu & McBride-Chang, 2006

- ◎ A multidimensional concept that captures family capital
  - **Financial capital** (monetary and material resources)
  - **Human capital** (educational and cultural resources)
  - **Social capital** (social connections linked with work, career and the like)
  
- Known to affect cognitive, linguistic and literacy development from as early as 4 months of age
- Aram, 2018; Asaridou et al., 2017; Brito & Noble, 2018





# Results

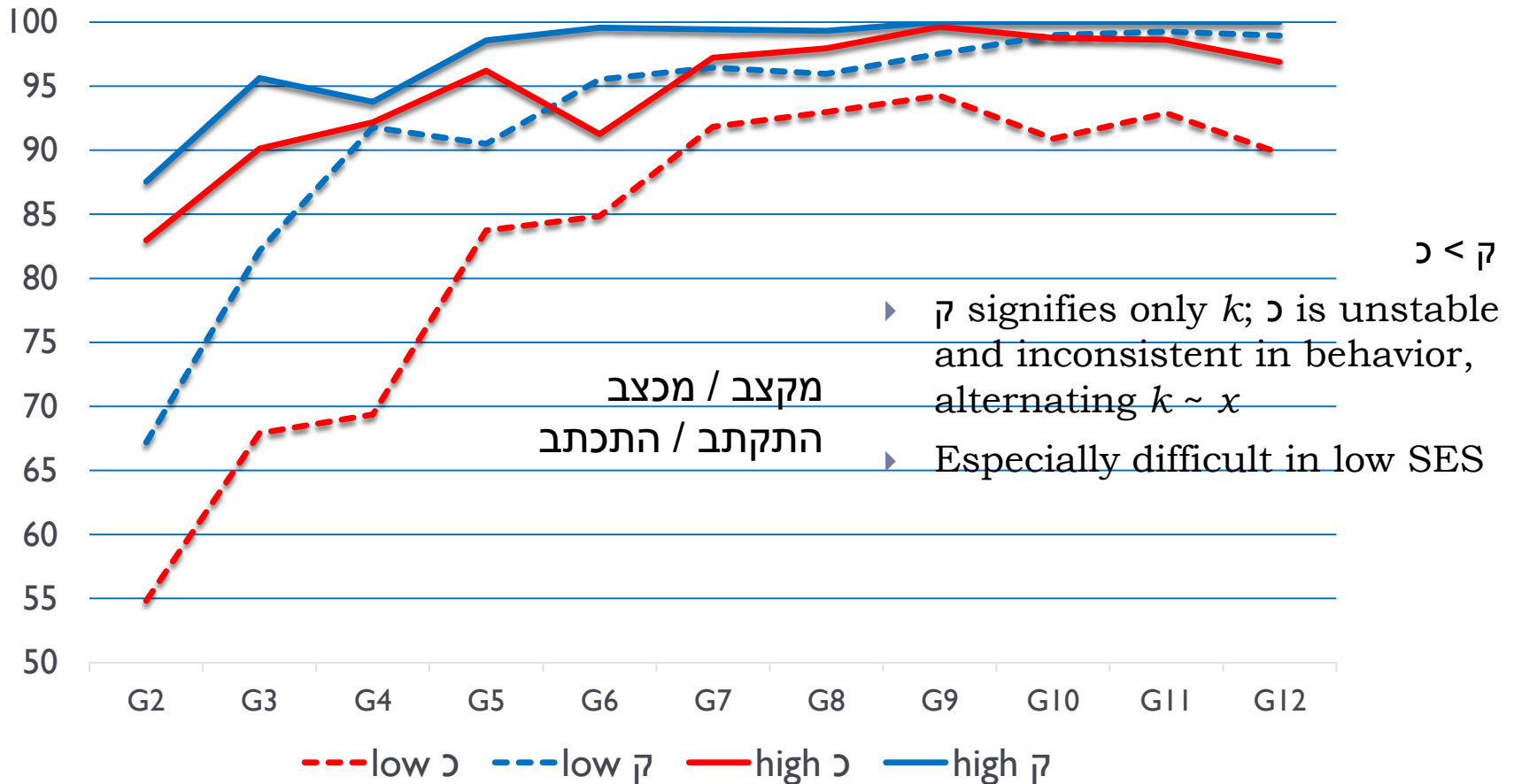
# Frequencies of root letters

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- ▶ Taken from Grunewald (2014) [MA thesis, TAU] on verb spelling in school texts for grades 1-2
- ▶ 6,357 word tokens, 24,841 letters
- ▶ 1431 verb tokens, 361 root tokens
  
- ▶ Where we specify root letter frequency it has two meanings:
  - ▶ Frequency in specific root positions (initial, medial, final)
  - ▶ General frequency as a root letter (out of all root letters)

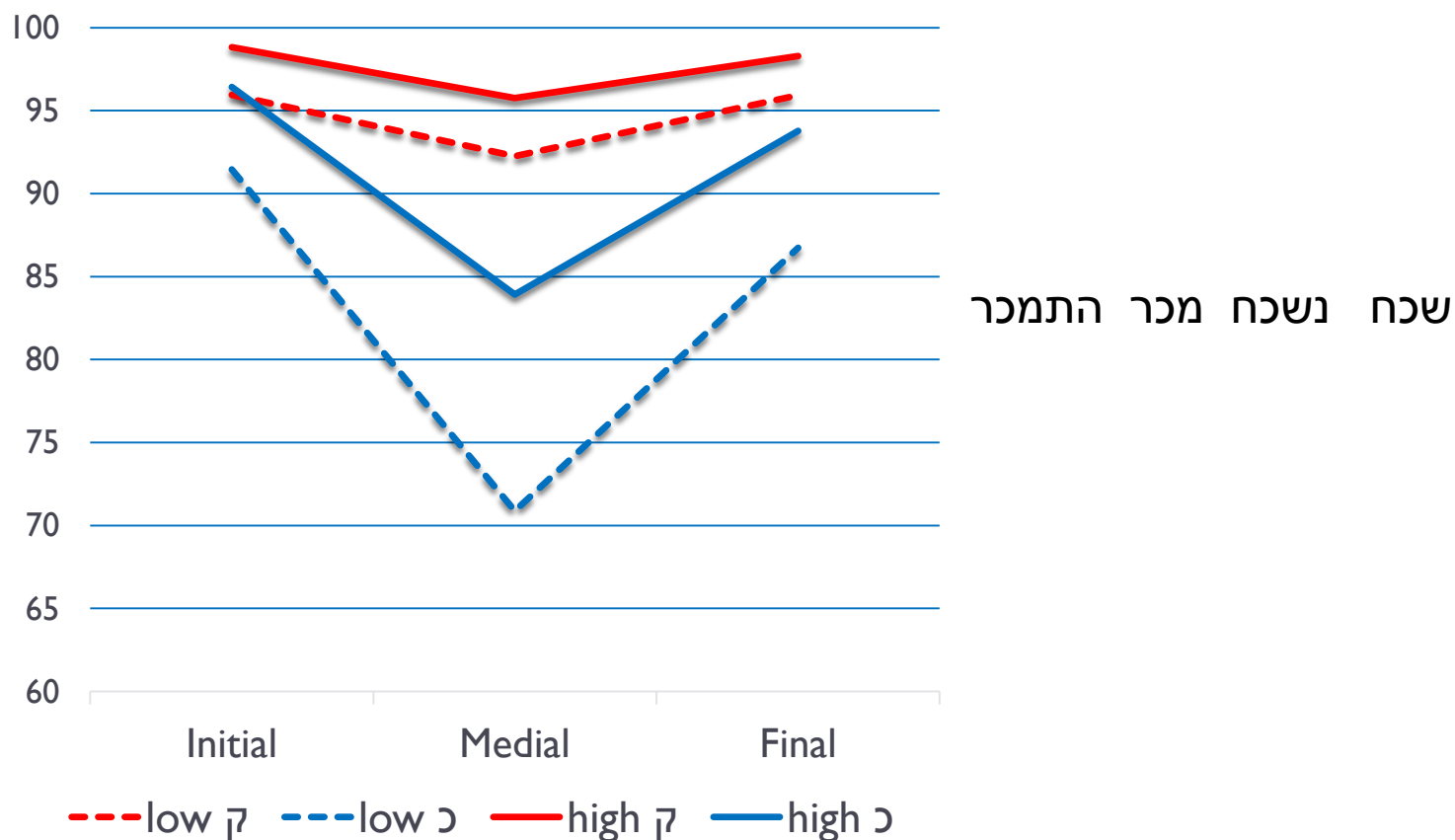


# Correct judgment of כ vs. ק in representing $k$ by grade level and socio-economic background



# Root site and SES in correct judgment of כ vs. ק in representing *k*

כ in medial position is most difficult; this position takes both stop and spirant, especially in low SES



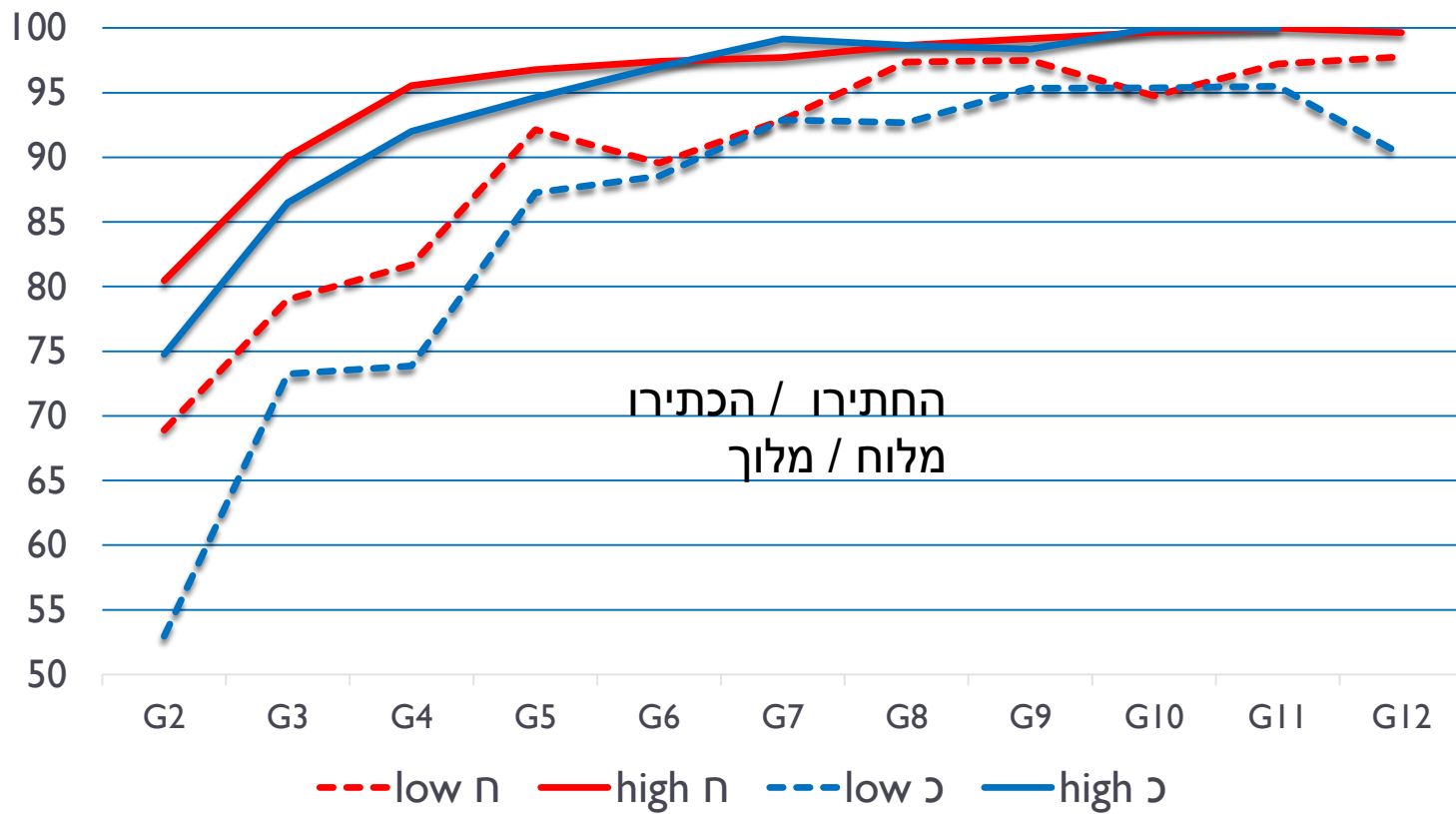
ק slight frequency advantage in initial and medial positions, big advantage in final position; ק tokens 5.1%, כ 3.8% tokens (Grunewald, 2014)



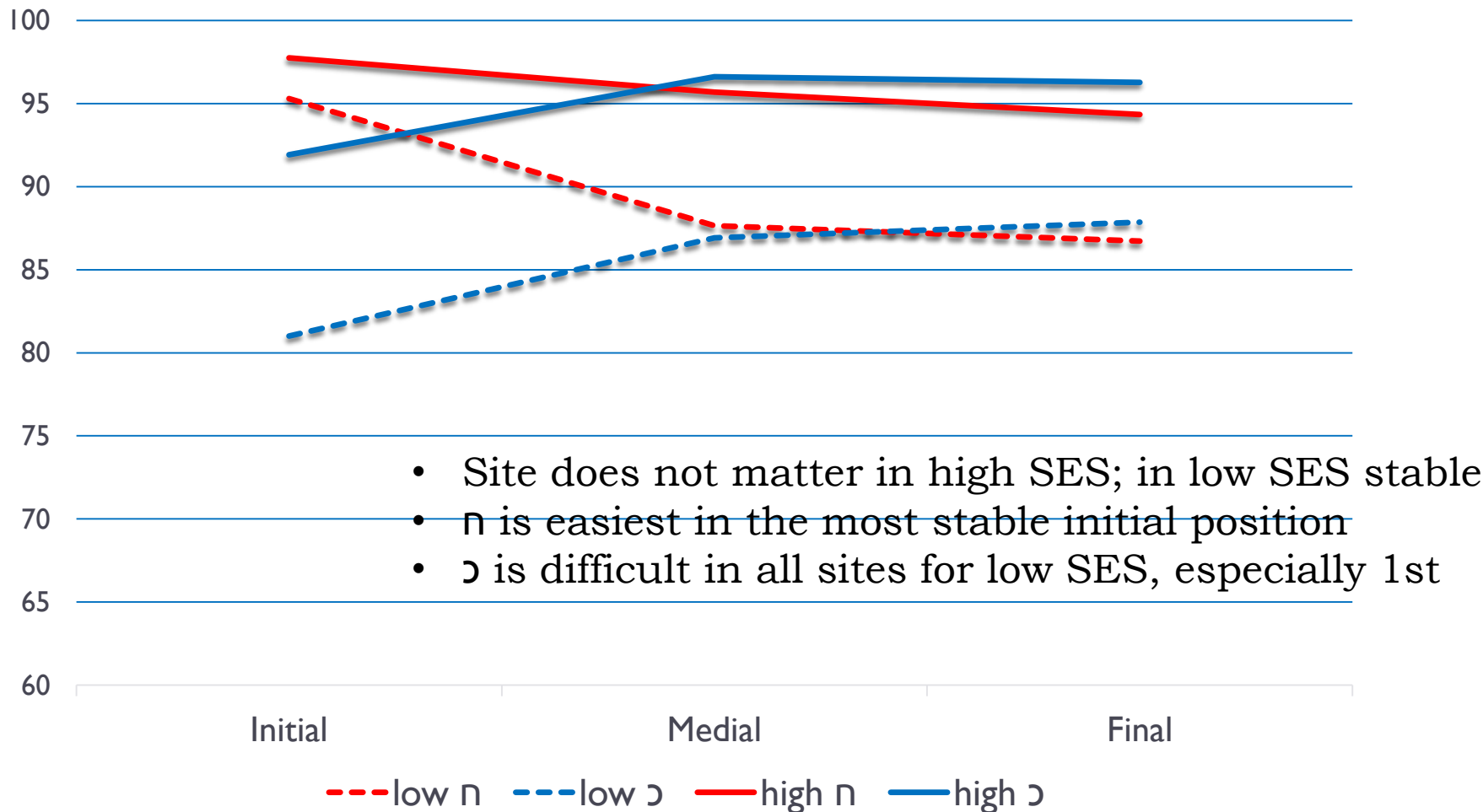
# Correct judgment of כ vs. ה in representing x by grade level and socio-economic background

כ < ה

ה is consistent; כ is inconsistent  
Almost no difference in high SES

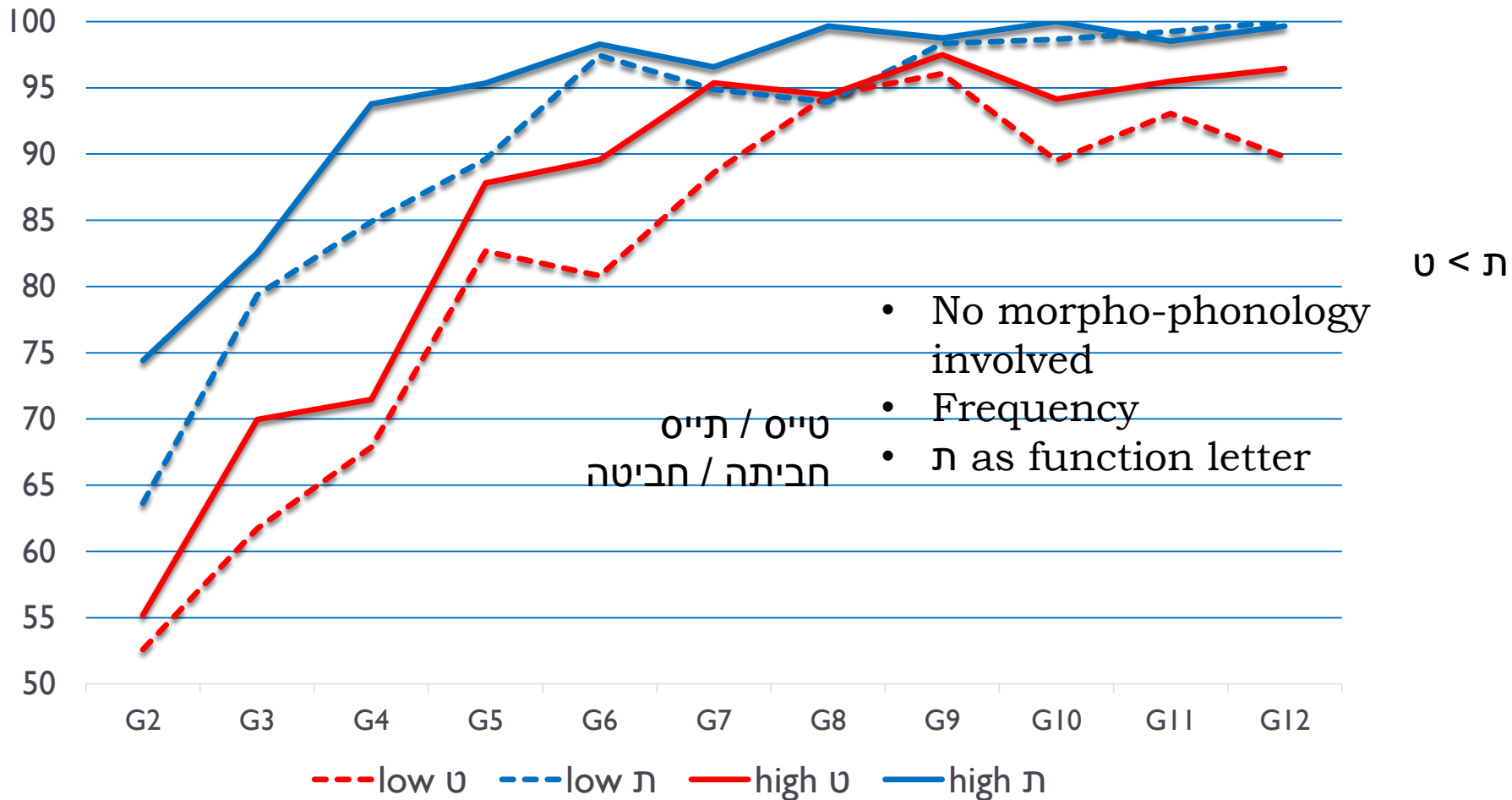


# Root site and SES in correct judgment of $\eta$ vs. $\zeta$ in representing $x$



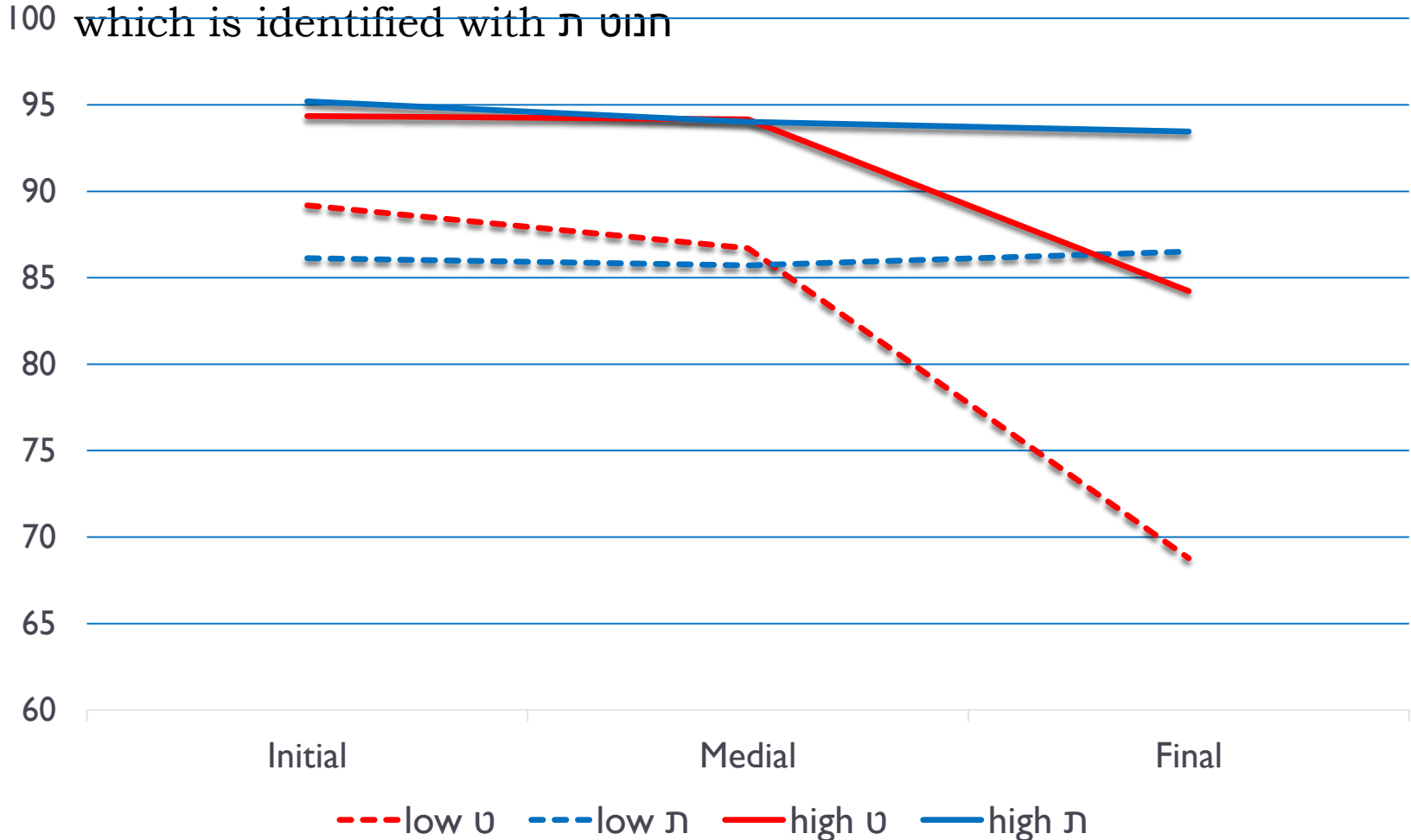
►  $\eta$  more frequent in first and final positions;  $\zeta$  slightly more in medial position  
Token frequency:  $\eta$  6.2%.  $\zeta$  3.8%

# Correct judgment of ת vs. ט in representing *t* by grade level and socio-economic background



# Root site and SES in correct judgment of ת vs. ט in representing t

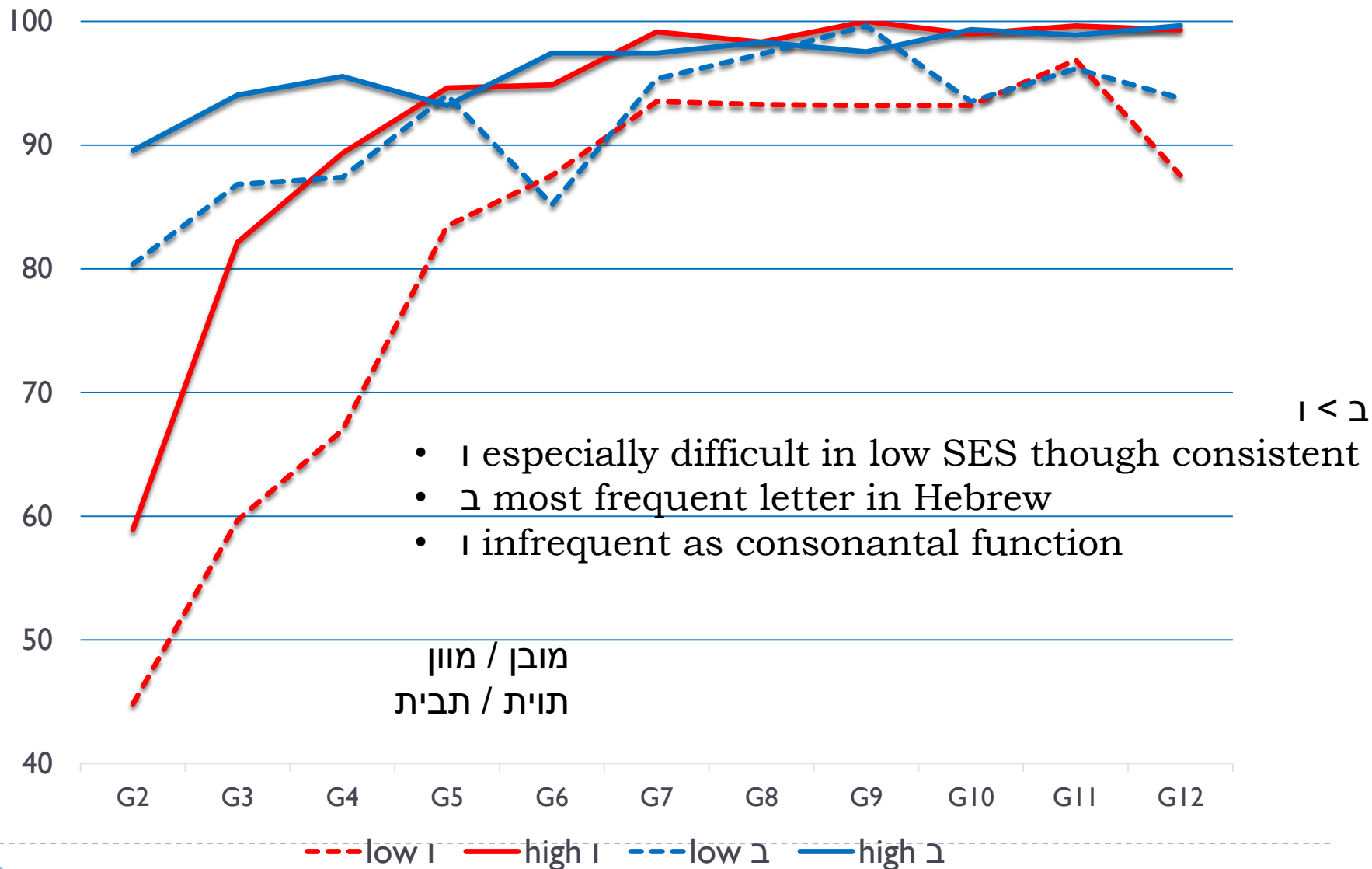
- ▶ Clear difference between SES; ט most difficult at word final position which is identified with ת חנט ח



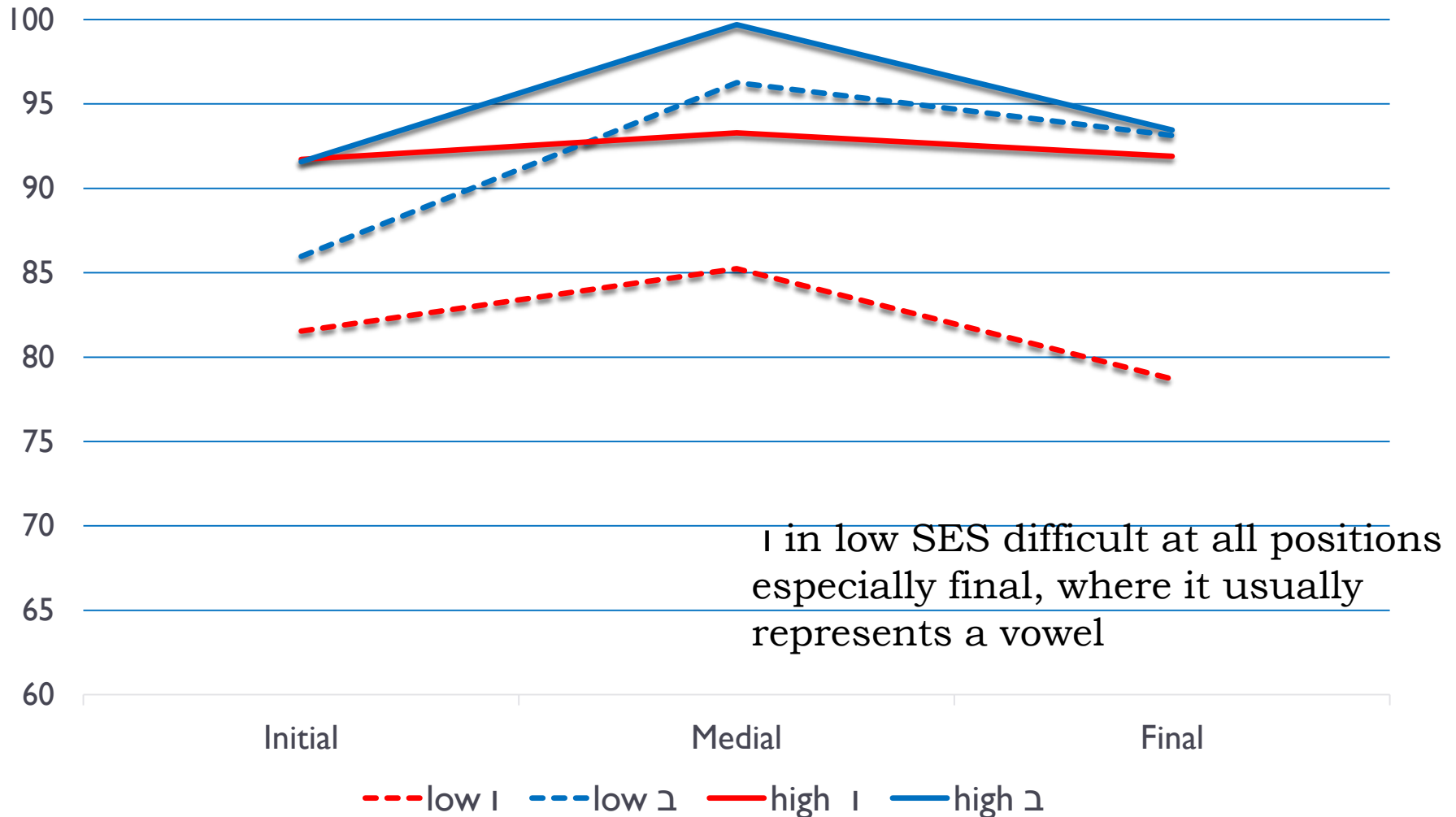
ט, ת same frequency in initial and medial positions; ט more frequent in final position

Token frequency: ט 1.3%, ת 1%

# Correct judgment of ו vs. ב in representing ו by grade level and socio-economic background

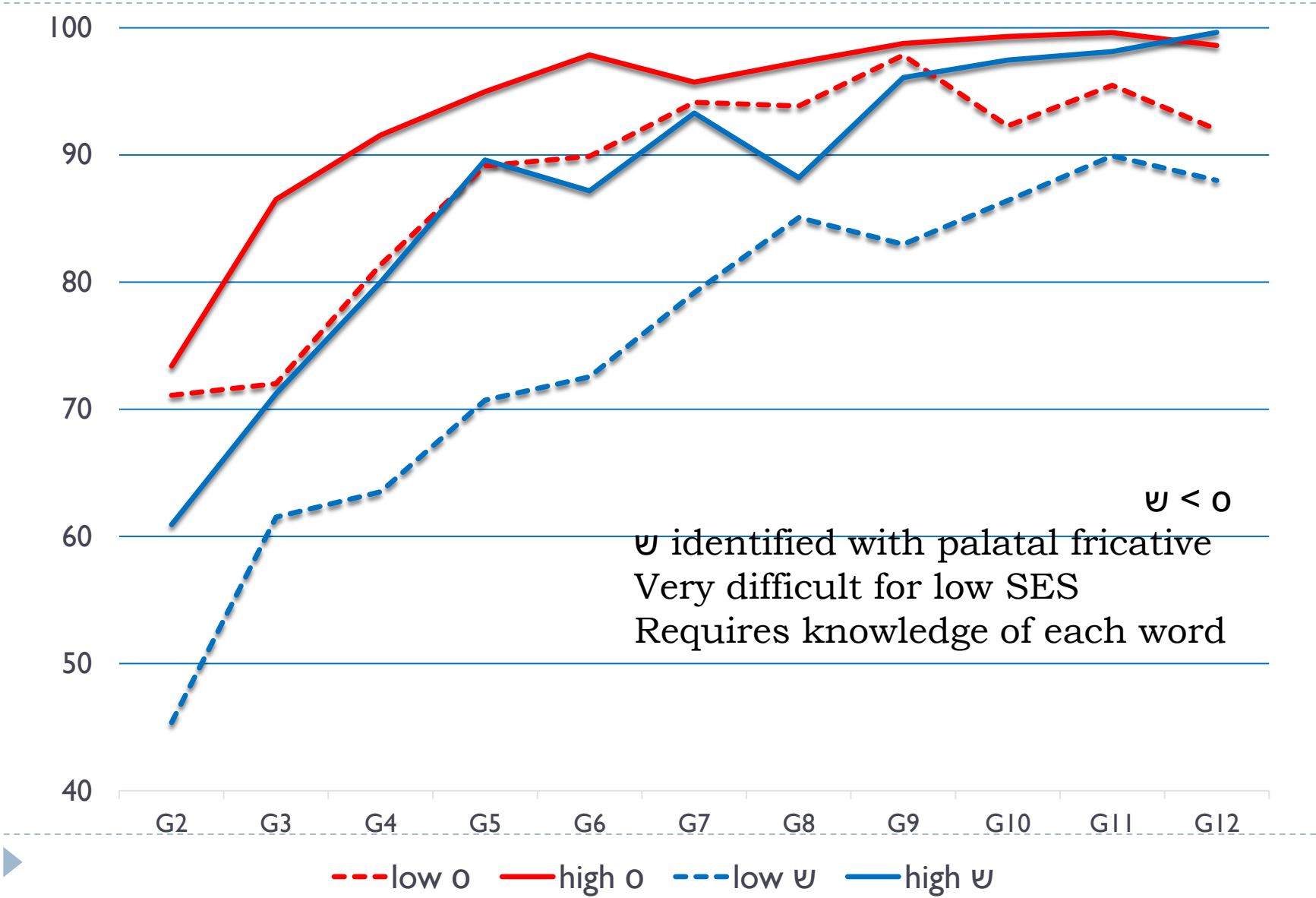


# Root site and SES in correct judgment of **ו** vs. **ב** in representing **ו**

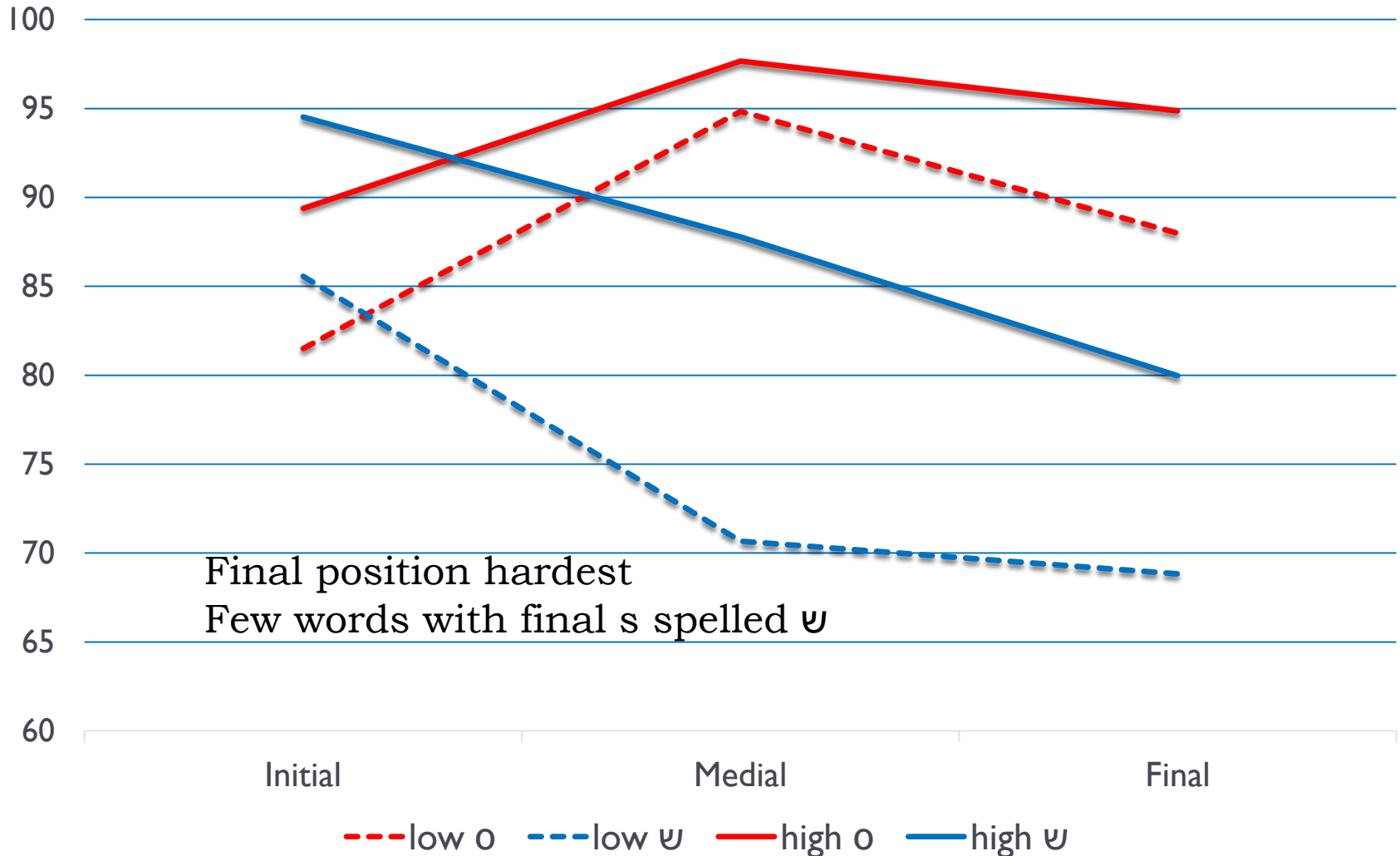


**ב** much more frequent than **ו** in first and final positions; medial position **ו** 7%, **ו** 1%

# Correct judgment of **ʃ** vs. **o** in representing **s** by grade level and socio-economic background



# Root site and SES in correct judgment of **ʁ** vs. **o** in representing **s**



o more frequent (highly) in all positions; o 3.4%, “left ʁ” 1.2%



# discussion

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# Population: development

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- ▶ Clear developmental trajectory testifying to learning the behavior of consonantal root letters
- ▶ High SES participants internalize the morpho-phonographic behavior of homophonous consonantal root letters across gradeschool and highschool
  - ▶ By 6th grade high SES students reached 90% even on categories where they had low success at earlier grade levels
- ▶ Development usually in pairs of consecutive grade levels, and most higher grades did not differ from each other



# Development: SES

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- ▶ The SES discrepancy was found across the board
- ▶ The study involves roots, basic lexical units in Hebrew
- ▶ Beyond the practical business of spelling errors, results thus point a low SES difficulty at extracting phonological, grammatical and lexical information from the encounter with written words



# Root letters with stop / spirant alternation

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ן ,ך vs כ ▶

- ▶ ך and ן both consistent phonologically
  - ▶ Higher frequency ך,ן than כ
- ▶ ך stop, ן fricative and also associated with low vowels
- ▶ Both only root letters
- ▶ כ not only inconsistent morpho-phonologically but also both function and root letter
- ▶ Necessitates deep familiarity with the morpho-phonological structure of the Hebrew lexicon
  - ▶ Frequent syllable structures
  - ▶ Associated with morpho-lexical categories

▶ Lexical quality

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# Root letters with stop / spirant alternation

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כ vs. ך ▶

- ▶ Though ך is phonologically stable it virtually does not exist as a consonantal root letter
  - ▶ Especially not in final position
- ▶ Consonantal role as word prefix - conjunction
- ▶ Vocalic role as word suffix
- ▶ Root כ prevalent at all positions
  - ▶ Stop / spirant alternation less of a problem
  - ▶ Identified with כ
  - ▶ Unlike the ך that has strong competitors



# Non-alternating pairs

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ו .vs נ ▶

- ▶ Although ו is only a root letter it is rare
- ▶ נ is one of the most prevalent consonantal letters in Hebrew
- ▶ Many roles as function letter, especially in final position
- ▶ Similar frequency of ו, נ as root letters in initial and medial sites, ו more in root final site



# Non-alternating pairs

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ψ vs 0 ▶

- ▶ 0 only root letter
- ▶ ψ root and function letter
  - ▶ Associated only with š



# Psycholinguistic implications

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- ▶ The study points at the necessity of deep and detailed familiarity with nominal and verbal patterns and stems and how roots are implemented in them
- ▶ Especially how roots with alternating *bkp* occur in them
- ▶ Despite the orthographic competition between stops and spirants from different sources, the very morpho-phonological phenomenon facilitates learning
- ▶ In sets where this alternation is absent, spelling
- ▶ success is lower



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**Thank you**

**תודה**

