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ORIGINAL PAPER

Morphological Analogies in Hebrew-Speaking University Students with Dyslexia Compared with Typically Developing Gradeschoolers

Rachel Schiff · Dorit Ravid

Abstract Little attention has been devoted to date to the study of morphological knowledge in individuals with developmental dyslexia. The current study compares the ability of Hebrew-speaking adult dyslexic students and gradeschool children to analyze written words into their morphological components, using a linguistic analogy task. Two sets of monolingual Hebrew-speaking participants—152 typically developing gradeschool children and 38 undergraduate students diagnosed with reading disabilities—were administered the Morphological Analogies Task. Results indicate an early ability of normally developing children to perform morphological analogies, while the adult dyslexic group performed on par with 3rd and 4th grade. Error analysis revealed that the overwhelming majority of the erroneous responses in all grades involved morphological strategies rather than the associative semantic strategy. However, the adult dyslexic students had many more associative responses than the graderschoolers. This testifies to the reduced written morphological abilities of adult dyslexic students.

Keywords Developmental dyslexia · Morphology · Morphological analogies

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Introduction: meta-linguistic knowledge in dyslexic populations

Developmental dyslexia is characterized as a specific functional failure to acquire the age-appropriate reading skills in otherwise normally developing children (Curtin, Manis, & Siedenberg, 2001; Stanovitch, 1988, 1989; Vellutino, 1979). Individuals with developmental dyslexia typically exhibit a major difficulty in single word recognition (Stanovitch, 1991). Showing poor performance in non-word repetition (e.g., Snowling, 1981) and non-word reading (Rack, Snowling, & Olson, 1992). The persistence of difficulties in phonological word decoding in well-compensated adult dyslexics (e.g., Bruck, 1992) suggests that the core problem in developmental dyslexia in a phonological deficit in the form of ineffective or immature phonological representations (Curtin et al., 2001). These findings have led to the formulation of the phonological deficit hypothesis, which proposes that developmental dyslexia results from an underlying phonological impairment (Frith, 1985; Shankweiler et al, 1995; Stanovich, 1988). This deficit is expressed in a reduced ability in dyslexics to manipulate phonological units (Bradley & Bryant, 1985; Mann, 1991). Our study is concerned with a different aspect of linguistic knowledge in dyslexics—morphological awareness.

Morphological reasoning

Language users may be required to consciously access, discuss, and verbalize their language knowledge more explicitly. In such cases, children and adults evidence *meta-language* or *language awareness*, the ability to think about language as an object from without (Chaudron, 1983; Gombert, 1992; Karmiloff-Smith 1986, 1992). This alternative mode treats language as a formal problem space, focusing analytically on its components as a cognitive goal in its own right. Meta-linguistic awareness requires the ability to introspect on the linguistic components that blend together naturally in language usage—phonemes, morphemes, words, syntactic structures, and discourse types. Thus it involves an analytical perception of units of language, the ability to represent on each unit separately, disassociating form from semantic content, and conscious monitoring of one's own linguistic knowledge (Bialystok, 1986; Valtin, 1984).

The specific ability of readers to reflect upon the meaning of morphemes, to parse and manipulate them, is termed 'morphological awareness.' Tasks involving morphological awareness request participants, for example, to judge whether words that share letter combinations (e.g., *person/personal*) are related, or ask them to complete a sentence with a derived form of a target word (e.g., *my uncle is a farmer*, derived from *farm*) (Carlisle, 1995, 2000; Fowler & Liberman, 1995).

A growing body of psycholinguistic research investigates how morphological structure constrains the recognition of printed words, especially through the priming paradigm (Drews & Zwitserlood, 1995; Feldman, 2000). Findings obtained in Hebrew show that the exposure to the Semitic root morpheme facilitated the identification of words from the same morphological family, i.e., derived from the same root (Deutsch, Frost, & Forster, 1998; Frost, Forster, & Deutsch, 1997). This facilitation effect is taken as evidence for the sensitivity of readers to the morphological structure of words. It is thought to be a transfer effect: that is, the information related to the shared base morpheme is extracted from the prime and transferred to the processing of the target. Results from numerous studies show that morphological priming is a robust effect that

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may serve as an important tool for investigating how morphological information is represented in the mental lexicon and manipulated in the course of word recognition (Schreuder & Baayen, 1995).

While the relationship between phonological awareness, reading and dyslexia has been extensively studied, less is known about the relationship between morphological awareness and reading ability; probably because of the view that problems in morphological analysis are a by-product of phonological factors (see Mann, 2000 for a discussion). Nonetheless, studies show that morphological awareness is related to reading ability (Carlisle & Nomanbhoy, 1993; Fowler & Liberman, 1995). Importantly, morphological awareness contributes to reading ability over and above the contribution of phonological awareness (Singson, Mahony, & Mann, 2000). The importance of morphological awareness to reading is most pronounced in the middle school years and beyond (Carlisle, 2000; Mahony, 1994; Shankweiler et al, 1995). The reading vocabulary of English-speaking children in these years begins to contain many multimorphemic words (Anglin, 1993) and readers may use the meaning of morphemes to compute the meaning of complex words in texts.

So far, little attention has been devoted to the study of morphological awareness in individuals with developmental dyslexia. Joanisse, Manis, Keating and Seidenberg (2000) found that dyslexic show below normal age performance in tasks demanding knowledge of regular and irregular English inflections. This result indicates that their behavioral impairment was not limited to phonological decoding and phonemic awareness. However, from a typological point of view (Croft, 1992) English inflections are not very rich and have a significant phonological component; hence there is a need to extend investigation to a wider variety of forms and to languages with richer morphologies. A second study was conducted in Hebrew by Ben-Dror, Frost and Bentin (1995) on a group of children (10–12 years of age) with learning disability who had severe reading problems. This group was found to be inferior to both age-control and reading-control groups in their performance in semantic judgment, phonemic awareness tasks, and a morphological awareness task. Interestingly, their relative impairment was most pronounced in the morphological task.

Taken together, these studies suggest that reading disability involves deficiencies in several linguistic domains, not only in phonological processing; and that languages with rich and complex (especially derivational) morphologies such as Hebrew pose a greater challenge for individuals with dyslexia. A recent study by Schiff & Ravid (2004b) examined the ability of adult dyslexic students compared with normal readers to judge whether written strings containing the Hebrew letter W were spelled correctly in various contexts. Dyslexic readers had lower scores than normal readers on accurate lexical decisions, and they took more time over these decisions. They also exhibited some deviant patterns indicating that they cannot make use of orthographic and morphological cues which are available to normal readers. The results of both adult populations were compared to those of normally developing 2nd and 4th graders (Ravid & Schiff, 2004). The adult dyslexics performed very similarly to the 2nd graders, while normally developing 4th graders performed similarly to normal adult readers. Thus normally developing 2nd graders eventually reach the pattern depicted by normal adult readers, but adult dyslexics' predicament is consistent and constant, showing their representation of spelling patterns to be qualitatively deviant from that of normal readers. These results indicate that Hebrew-speaking adult dyslexics lack the orthographic and morphological skills that adults without a reading impairment rely on in processing written Hebrew. Given this background, the current study com-

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pares the performance of Hebrew-speaking adult dyslexic students and gradeschool children on analyzing written words into their root and pattern components, using a linguistic analogy task.

Introduction: non-linear semitic morphology

Morphology is one of the organizing principles of the mental lexicon (Aitchinson, 2003; Marslen-Wilson, 1999). It is especially important in the highly synthetic Semitic languages, Hebrew and Arabic, where word structure expresses a rich array of semantic notions (Bolozky, 1999; Boudelaa & Marslen-Wilson, 2001; Deutsch & Frost, 2002). Unlike words in English, the basic morphemes that make up Hebrew words are discontinuous, that is, they are not sequentially ordered (Berent & Shimron, 2002; McCarthy, 1981). The two basic morphological entities in Hebrew and Arabic are the Semitic root and pattern, two interdigitated morphemes which together create the basic Hebrew word (Berman, 1987; Ravid, 1990; Schwarzwald, 2001). For example, root $g-d-l$ 'grow' and pattern *CaCoC* (C's refer to root consonants) combine together to yield adjective *gadol* 'big.' The current study aims to evaluate the developing ability of Hebrew-speaking gradeschool children to analyze written words into their root and pattern components, using a linguistic analogy task.

We start by presenting the two constructions under study, the root and the pattern, from linguistic and psycholinguistic perspectives. The better known and widely analyzed component of the two is the root, the lexical core of the Semitic word. In speech, the Semitic root is a discontinuous morpheme, usually consisting of three to four consonantal radicals (e.g., $g-d-l$ 'grow'). The spoken root is not a pronounceable or semantically independent entity, but it carries a core meaning which serves to relate all members of the morphological family (Baayen, 1994). The fuzziness of its core semantics, coupled with the nonlinear apparatus (see below), fosters the derivation of numerous related words all clustering around the same root, which in other languages might be expressed by non-related lexemes (Ravid, 2001; Schwarzwald, 2001). Fort example, root $g-d-l$ carries the basic meaning of 'grow', and serves to relate a large morphological family of verbs, nouns and adjectives:[1] *gadal* 'grow,' *gidel* 'raise,' *gudal* 'be raised,' *higdil* 'enlarge, *hugdal* 'be enlarged,' *gdila* 'growing,' *gidul* 'growth,' *hagdala* 'magnification,' *gdula* 'eminence,' *gódel* 'size,' *migdal* 'tower,' *megadel* 'grower,' *magdélet* 'magnifying glass,' *gadol* 'big,' *megudal* 'grown.'

Given its central role in Semitic word structure, it is no wonder that root perception is an inherent component of Semitic lexical and morphological knowledge. A large body of research indicates that the root has a central role in the organization of the lexicon in Hebrew and Arabic speakers (Abu-Rabia, 2002; Boudelaa & Marslen-Wilson, 2001; Ravid, 2002). A number of researchers have shown that the root occupies a separate level of representation in the mental lexicons of spoken and written Hebrew and Arabic (Berent & Shimron, 1997; Bolozky, 1999; Mimouni, Kehayia, & Jarema, 1998), and that it is an essential component in reading and writing processes (Frost et al., 1997; Ravid, 2001, 2002).

Root awareness is an early and pervasive ability in Hebrew speakers. For example, Ravid and Bar-On (2001) show that the ability to retrieve root-related words

[1] Verbs are presented in the past tense, masculine singular form, since there is no basic or uninflected verb form in Hebrew.

from the mental lexicon starts early and increases with age and schooling, especially between adolescence and adulthood; and that regular roots are easier to retrieve than irregular or defective roots. Preschool children demonstrate very early perception of roots (Ravid & Malenky, 2001) and an even earlier ability (as young as age two) to extract roots from words and make up new words with them (Berman, 2000; Clark & Berman, 1984). The only other language for which we have some information about Semitic root development is Arabic, where recent research indicates a stronger and earlier root awareness than in Hebrew (see summary in Ravid, 2002; and see also Ravid & Farah, 2001).

Given that the root is bound and discontinuous in nature, it must combine with the *pattern*. Spoken patterns, like roots, are not pronounceable units; rather, they are prosodic templates into which root radicals are 'poured' at specified slots, and which may be preceded and/or followed by consonantal affixes. For example, pattern *CaCoC* (e.g., *gadol* 'big') consists of two vowels, *a* and *o*, interdigitated by three slots for root radicals, with ultimate stress (Schwazwald, 2002). The combination of the root with different patterns yields the morphological family clustering around that root (Bolozky, 1999).

Pattern semantics is inherently different from that of roots. It is categorical rather than lexical, as patterns classify verbs, nouns, and adjectives into categories comparable to English derivational suffixes such as *–ize, -ic, -ity*. For example, the combination of root $s-g-r$ 'close, shut' with various patterns[2] yields verbs *sagar* 'close,' passive *nisgar* 'be closed,' causative *hisgir* 'extradite,' reflexive *histager* 'close oneself;' passive resultative adjectives *sagur* 'closed' and *mesugar* 'introvert;' and verb-derived nominals *sgira* 'closing,' *hasgara* 'extradition,' *sgirut* 'introvertedness,' *histagrut* 'self-closing,' *séger* 'closure,' *misgéret* 'framework,' and *sagir* 'coda.'

Although very young children are easily able to extract roots out of words and combine them with patterns (Berman, 1985; Ravid, 1995; Ravid & Farah, 2001), developmental studies indicate that perception and explicit awareness of patterns emerge much later than root awareness (Ravid, 2002; Ravid & Malenky, 2001). This late development may result from 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. On the one hand, Deutsch, Frost, & Forster (1998) and Deutsch & Frost (2002) report findings from Hebrew that verbal patterns prime words while nominal patterns do not. This 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. On the other hand, Boudelaa & 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. The question of the status of nominal patterns thus remains open.

Written Hebrew morphology

The written structure of non-linear Hebrew words guides its writers/readers toward a more discrete perception of morphemes.[3] Spoken roots often contain the stops p, b, kwhich alternate with corresponding spirants f, v, x (Bolozky, 1997). This is a

[2] Stress is not marked unless penultimate (Bolozky, 1997).

[3] Spoken Hebrew is represented by lowercase italics, written Hebrew by capital Latin letters.

fundamental and pervasive feature of Modern Hebrew phonology, which children learn and manipulate early on in acquisition (Ravid, 1995). As a result, spoken roots are highly allomorphic with phonological alternants of the same root. For example, root $p-z-r$ 'scatter' alternates with allomorph $f-z-r$, as in *pizer* 'scatter' or *pazran* 'spendthrift' versus *mefazer* 'scatters' or *mefuzar* 'scatterhead.' Stop/spirant alternation may interfere with the oral representation of the root as a unified entity (Ravid & Bar-On, 2005). But in the written language, orthographic form helps in perceiving all root variants as a single unit, since both the stop and spirant alternants are represented by a single grapheme in non-vocalized Hebrew: p/f by P פ; b/v by B ב; and k/x by K כ. For example, all wordforms sharing the three variants of root *k-t-b* contain the grapheme sequence KTB כתב (underlined), e.g., *hitkatev* 'correspond,' spelled HTKTB התכתב, *hixtiv* 'dictated,' spelled HKTYB הכתיב and *ktuba* 'marriage contract,' spelled KTWBH כתובה (Ravid & Bar-On, 2005).

Moreover, written Hebrew obscures the discontinuous nature of basic spoken derivational morphology by presenting roots and patterns as distinct entities, seeing that root letters very often appear as a continuous sequence. For example, *gadal* 'grow' is spelled GDL גדל or גָּדַל; *migdal* 'tower' is spelled MGDL מגדל or מִגְדָּל. In both of these cases, the written root GDL גדל appears as a continuous sequence of letters, whereas the spoken root morpheme is split by the pattern vowels. Writing thus encourages the perception of the written root morpheme as a discrete word component.

This is not to say that root letters always appear as a written linear sequence, as in many cases roots are interdigitated by letters even in writing, e.g, *gadol* 'big' spelled GDWL גדול. But since only two vowel letters are allowed to appear between root letters,[4] (e.g., *gdila* 'growing' spelled GDYLH גדילה), this considerably diminishes the number of split roots in written Hebrew (Frost, 1995). Written patterns are expressed as distinct from roots by appearing as a distinct root-external 'envelope' of the orthographic root (Ravid, 2001). For example, root GDLגדל in *migdal* 'tower,' spelled MGDL,מגדל is preceded by prefix M standing for pattern *miCCaC*. These orthographic features may encourage the representation of the pattern as a separate morphological entity, on the one hand, but also hinder its identification and formal manipulation.

This layered structure of written morphological constructs in Hebrew has important implications for reading and for writing, because experienced Hebrew readers will know that the lexically meaningful part of the word is represented in its center, while letters framing the word carry grammatical and categorial meaning. For example, the sequence WKŠBMGDLYKM וכשבמגדליכם pronounced *u-xshe-be-migdaley-xem* 'and-when-in-towers-yoursPl' is typical of written Hebrew, with root GDL 'grow' surrounded by function elements.

The study

A previous study focusing on high-SES gradeschoolers' ability to solve different types of verbal analogies (Ravid & Schiff, 2006) showed that by 6th grade, typically developing children performed almost at ceiling. Given this fact, and because it is clear that dyslexic students have lower verbal analytic abilities than their peers, our current study had two goals: one, to place adult dyslexics on the developmental continuum

[4] The only exception is the metathesis in the verbal pattern *Hitpa'el* (Schwarzwald, 2001).

compared with schoolage children regarding morphological abilities; and two, to find out whether the performance of adult dyslexic students and normally developing children is qualitatively different.

The current work thus investigated the ability of groups of Hebrew speakers-typically developing children and dyslexic university students—to analyze roots and patterns in written Hebrew nominals using a linguistic analogy task. This design enabled us to present both groups with written non-linear words together with corresponding words containing similar roots and patterns to see whether they were able to relate word pairs through these morphemes. The fact that words were written eliminated any possible problems with participants' memory span and permitted them to focus on the orthographically visible relationships between test items. As shown below, participants were presented with various morphological options as possible responses. In addition to the correct form, there were root, pattern, and associative distracters, which enabled us to examine closely not only correct but also erroneous responses and the morphological abilities underlying them.

Given the fact that this work does not have any available precedents, we did not have straightforward predictions regarding the dyslexic students, although we had grounds to hypothesize that they would not do as well as the oldest gradeschoolers. We could however predict more success with root-structure than with pattern structure, to be expressed in more root-related than pattern-related errors (Deutsch et al., 1998; Ravid, 2002; Ravid & Malenky, 2001).

Participants

Our population consisted of two sets: (1) Typically developing monolingual Hebrew-speaking gradeschool children from middle-high SES background with no diagnosed language or learning disabilities. A prior trial with 30 adult normal readers showed that they all had ceiling scores; moreover, as we show below, the gradeschool participants scored close to ceiling by 6th grade. Thus there was no use in taking a control adult student group. (2) Dyslexic university students from middle-high SES background (see below).

Children

About 152 gradeschool children participated in the study (2nd, 3rd, 4th, 5th and 6th graders), all monolingual speakers of Hebrew as a native tongue from a middle-high SES background, with no diagnosed language or learning disabilities. They were administered the analogies test (see below) in writing in the class forum. Prior to the experiment, 58 additional participants were screened out by two measures: the Raven IQ (M = 108.4, SD=12.6) and the Mann test of verbal analogies [M = 11.9, SD=2.4 (general population mean 10, SD=1.5)]. These ensured that all remaining participants (152) had normal intelligence and were able to understand the concept of analogy.

Adults

About 38 undergraduate education students, all with a long history of reading difficulties and diagnosed with reading disabilities within three years prior to attending university or while attending university, were randomly selected from a group of students involved in a learning disabilities support group. A comparison group consisted of 38 volunteer participants, all undergraduates who were accepted into the control group if they perceived themselves as average readers, with no history of learning or reading problems, were not taking medication, and had not repeated a grade. All participants were monolingual native Hebrew speakers. There was an equal number of males and females in both groups, and the age range of participants was 20–26 (Israeli students are typically older than their American and European peers, in view of the fact that they only start University after a military service of 2–3 years). Mean age is 23;5, SD=1.83.

Selection of materials

In the absence of updated word frequency tables in Hebrew, we proceeded in two stages. First, 30 gradeschool teachers screened 80 nouns for their frequency on a scale of 1–5. 40 nouns with medium frequency (2.8–3.4) were selected out of the initial list. These made up our list of 40 target nouns. The target nouns were rated by their degree of familiarity (Nelson & Kuera, 1982) by the children who participated in the study 2 months before administering the task. Participants were asked to rate each noun by familiarity on a scale of 1–3: (1) I don't know this word; (2) It is familiar; (3) It is very familiar (converted to 100%). Agreement among participants on familiarity was 90%. Table 1 presents the difference in familiarity by grade.

As the familiarity scores revealed differences among grades, we conducted another one-way ANOVA by grade, controlling for word familiarity. Since no differences were found between the results with and without control, we present the results without control. The one-way ANOVA on the data in Table 1 showed an effect of grade [$F(4, 147) = 11.13$, $p < 0.001$], but the Post Hoc Scheffé test (which groups homogeneous subsets at the 0.05 level) showed that only the 2nd graders differed from the other groups. Even in this youngest group, target nouns were mostly familiar or very familiar to participants (80.57%).

Task structure

The Morphological Analogies Task (MAT) was specially designed for this study, based on the general cognitive foundations laid out in Sternberg (1977). It consisted of 40 analogy sets targeted on the 40 nouns whose selection procedure is described above. Each set contained two components: a set of stimulus nouns, and a set of possible responses. The task required the selection of a target noun from the set of responses to complete the stimulus set. See Appendix 1 below for a graphic delineation of the MAT and Appendix 2 for some Hebrew examples.

Each *stimulus set* was a four-sided structure consisting of two double pairs of morphologically related words (top and bottom, right and left) where the rightmost

Table 1 Mean degrees and standard deviations of familiarity of participants with target words (1–3 scale converted to 100%), by grade

Grade	Mean
Grade 2	80.57 (13.9)
Grade 3	94.38 (7.5)
Grade 4	95.08 (10.52)
Grade 5	98.17 (1.91)
Grade 6	90.97 (11.28)

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member at the bottom, the target noun, was missing. Table 2 presents an example of a stimulus set.

The members of each horizontal pair are related to each other through their root, and the members of each vertical pair are related to each other through their pattern. Participants were required to complete the analogy rectangle by selecting the target noun—the missing right-hand member of the bottom pair—from the response set. The target noun has to be related to the left member of its horizontal set (*root source*) by root, and to the top member of its vertical pair (*pattern source*) by pattern. Most left-hand members of the analogy sets were nouns or adjectives (the nominal class of Hebrew, Schwarzwald, 2001), a few were verbs. The right-hand members, including the target noun, were always nouns. We took steps to ensure that target nouns were not identified through rhyming by omitting patterns with stressed suffixed endings (e.g., agentive *CaCCan*) as targets and by selecting roots with dissimilar endings (see Ravid & Hanauer, 1998 for Hebrew rhyming theory and patterns). All roots selected for the MAT were regular and fully tri-consonantal with no missing elements (Ravid, 1995; Schwarzwald, 2001).

Each *response set* consisted of five options, randomized in presentation: (1) **Correct response**: the target noun (for the example in Table 2, MSRTH מסרטה, *masreta* 'projector'); (2) **Main root distracter**, a word containing the same root as the root source, but not the same pattern (For Table 2, TSRYT תסריט *tasrit* 'script'); (3) **Pattern distracter**, a word containing the same pattern as the pattern source, but not the same root (MGRPH מגרפה *magrefa* 'rake'); (4) **Secondary root distracter**, a word containing the same root shared by members of the top horizontal pair (KPYL כפיל *kafil* 'a double'). (5) **Associative distracter**, associated semantically or pragmatically but not morphologically to left-hand member of horizontal pair (root source) (KWLNW9 קולנוע *kolnóa* 'the movies').

In order to complete the stimulus set in Table 2 correctly (also see Appendix 1), participants had to go through the following steps:

- Analyze the morphological root-and-pattern structure of each of the double pairs constituting the given three-sided analogy structure;
- Detect the root relation between members of the top horizontal pair (KPL כפל) and infer a similar relation between the target noun and the left member of the bottom horizontal pair (root source), based on its root SR סרט;
- Detect the pattern relation between members of the left vertical pair (*CéCeC*) and infer a similar relation between the target noun and the top member of the right vertical pair (pattern source), having analyzed its pattern *maCCeCa.*
- Select the correct response which consists of root SRT and pattern *maCCeCa*, yielding MSRTH מסרטה).

Table 2 An example of the stimulus set

KPL כפל *kéfel* 'multiplication'	MKPLH מכפלה *maxpela* 'multiple,N'
SRT סרט *séret* 'film'	**?** (MSRŦH מסרטה **?** (*masreta* 'projector')

Procedure

Each participant received the MAT questionnaire in writing with three training items followed by the 40 task items. All words were vowellized with *nikud* diacritics to supply maximal phonological information and to prevent any ambiguous reading. Participants were told to complete each rectangle by marking one of the five response options in each task item.

Results

Table 3 presents the correct responses of the participants on the MAT. A one-way ANOVA on the data in Table 3 showed an effect of population ($F(5, 182) = 28.66$, $p < 0.0001$), with correct performance rising with age and schooling in the typically developing gradeschoolers. The Post Hoc Scheffé test grouped the two oldest gradeschool groups (5th and 6th) with the highest scores together, whereas the 2nd graders with the lowest scores were placed in a different subset. However, the adult dyslexics were grouped together with the two middle gradeschool groups (3rd and 4th).

We next proceeded to analyze the erroneous responses by error type. Each response set in the MAT had four distracters in addition to the correct response (Table 2, Appendix 1): (1) Main root distracter, related to left member of bottom pair by correct root, but not by correct pattern; (2) Pattern distracter, related to top member of vertical pair by correct pattern but not by correct root. (3) Secondary root distracter, related to top pair; (4) Associative distracter, related to left member of bottom pair. Table 4 shows the distribution of error types out of all erroneous responses by grade.

The data in Table 4 clearly indicate that the most frequent error was main root distracter. For example, *pazran* 'big spender' instead of *tifzoret* 'piecemeal,' sharing the same root with root source *pizur* 'scattering,' but not the correct pattern *tiCCóCet*, which should derive from that of pattern source *tisbóxet* 'complication.' All other error types did not exceed 5% in the gradeschool population. However, the adult dyslexics had over 28% of associative distracter responses. We conducted separate one-way ANOVAs on each of the error types. The *root responses* had an effect for population [$F(5, 152) = 5.93$, $p < 0.0001$]: The post hoc test showed that the dyslexic adult students differed from the 3rd and 6th graders who had a larger amount of root distracter errors, and they were placed in the same group as the rest of the gradeschoolers, with the lowest root distracter score in that subset. The pattern distracter and secondary root distracter responses showed no effect for population. However, the associative distracter showed an effect for population [$F(5, 152) = 23.44$, $p < 0.0001$], with the

Table 3 Mean percentages and standard deviations of correct responses on the MAT, by grade

Grade	Mean
Grade 2 *N*=**29**	56.15 (11.34)
Grade 3 *N*=**34**	72.0 (18.5)
Grade 4 *N*=**31**	76.62 (19.97)
Grade 5 *N*=**30**	90.69 (13.74)
Grade 6 *N*=**28**	94.14 (10.6)
Adult dyslexic students	68.57

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Table 4 The distribution of erroneous responses by category (distracter type) and grade

Grade	Main root distracter	Pattern distracter	Secondary root distracter	Associative distracter
Grade 2	83.06 (23.18)	2.56 (5.29)	7.06 (12.84)	7.33 (8.76)
Grade 3	94.76 (7.08)	0.20 (1.10)	2.4 (4.32)	2.65 (5.25)
Grade 4	88.14 (20.75)	1.42 (3.71)	4.03 (14.29)	6.41 (11.43)
Grade 5	79.40 (31.69)	8.16 (25.01)	8.48 (23.08)	3.96 (9.08)
Grade 6	92.96 (17.56)	3.7 (12.89)	1.11 (4.3)	2.22 (8.61)
Adult dyslexic students	70.77 (18.02)	0.24 (1.45)	0.89 (2.65)	28.1 (18.05)

dyslexic university students placed in a separate subset from all of the gradeschoolers, with the highest amount of associative distracters.

Discussion

This study investigated the ability of typically developing Hebrew-speaking gradeschool children and dyslexic university students to solve morphological analogies by completing sets of root- and pattern-related nouns using a closed set of responses. Two major findings arise from our study. On the one hand, results indicate an early ability of normally developing children to perform morphological analogies, making use of both root and pattern knowledge. By 4th grade, more than three-quarters of the results were correct, indicating familiarity with major patterns in Hebrew and the ability to extract roots and combine them with those patterns (Berman, 1987; Ravid & Bar-On, 2005). But in contrast, the adult dyslexic group was on par with the 3rd and 4th gradeschool groups: the two oldest gradeschool groups achieved much higher scores.

Error analysis again revealed important differences between normal development and the performance of the dyslexic adults. The developmental data show that the overwhelming majority (over 90%) of the erroneous responses in all grades involved morphological strategies (root and pattern distracters) rather than the associative semantic strategy. About 90% of these erroneous responses in all grades involved the root (main and secondary) rather than the pattern, which did not receive over 5% of the erroneous responses. However, the adult dyslexic students had fewer root distracter errors than all normally developing groups, and they had seven times as many associative responses as the 2nd graders, who had the largest amount of associative responses in the gradeschoolers. This means that they did not perform any written morphological analysis in close to 30% of the time.

Regarding the typically developing gradeschoolers, our results can only be interpreted as deriving from Hebrew-speaking children's ability to analyze nouns into both roots and patterns. Both correct and erroneous responses clearly indicate an early and robust perception of the Semitic root in Hebrew-speaking children, a finding which has strong independent support in other studies (Berman, 2002; Ravid, 2002). Noun patterns are also shown to have a central role in children's correct morphological performance, but they do not attract errors. We interpret this as further evidence to indicate that noun patterns take longer to establish and have frailer representations

(Frost et al., 1997; Ravid & Malenky, 2001). However, both roots and patterns participate in the selection of the correct response. This selection cannot be explained solely on the basis of root knowledge alone, given that the shape of the correct word is given by the pattern which must be discerned from the analogy set. As noted, it was possible in the MAT to select another noun with the target root and a different pattern from the response set ('pattern distracter'), but this happened rarely. We interpret these results to constitute evidence for the distinct roles of root and pattern morphemes in the organization of the Hebrew nominal lexicon as early as in gradeschool. The experiment shows that root awareness is the more central and robust of the two, and is present earlier in children; whereas perception the pattern is more fragile and emerges later in language development. These results are supported by independent evidence from previous studies (Ravid, 2002; Ravid & Kubi, 2003; Ravid & Malenky, 2001).

All the evidence points to extremely reduced analytical morphological abilities in the adult dyslexics. Their low score on the MAT, a meta-linguistic reading task indicates a reduced ability to analyze the internal construction of written words. Specifically, error analysis shows that they operate mostly on the global semantic aspect of language: They only produced main root or associative errors, and no pattern errors at all. Regarding the associative responses, these indicate the deviance of adult dyslectic readers in comparison with typically developing children. Associative distracters bore no morphological relationship to the target words, and thus required no morphological analysis.

We might ask ourselves how it is possible that these dyslexic adults could read at university level and yet not do as well as third graders on the MAT. First, note that reading comprehension in general, including word understanding is explained today by theories of Latent Semantic Analysis (LSA). LSA accounts for knowledge growth not only by direct application of the stored knowledge to problem solving, but also by the ability to add new knowledge to long term memory, to infer indirect relations among bits of knowledge and to generalize from instances of experience These general strategies do not require any phonological, orthographic, or morphological abilities, and they have been shown to underlie reading performance and lexical acquisition (Foltz, Kintsch, & Landauer, 1998; Landauer & Dumais, 1997). We assume that our adult dyslexics rely on these general strategies, enhanced by world knowledge and contextual clues, to extract meaning from texts.

Moreover, adult dyslexics are native Hebrew speakers, and despite their disability, rely to some extent on Hebrew-specific strategies to analyze both oral and written texts. Recent crosslinguistic research has demonstrated the powerful impact of target-language typology on the process of language learning from early preschool age in a range of domains, revealing that from very early on language users are sensitive to the 'typological imperatives' of their language (Berman, 1986). The Hebrew typological imperative is affected by its rich Semitic morphology, and channels Hebrew users towards morphological information within the Hebrew word (Ravid, 2005; Schiff, 2002). Dromi, Leonard and Shteiman (1993) compared morphological acquisition in Hebrew, English and Italian-speaking children with language impairment. Their results clearly indicate that the richer the morphology, the more it contributed to children's success in overcoming their disability, so that the Hebrew-speaking children with language impairment were found to perform the best of the three groups, followed by Italian and then English. Thus even individuals with reduced morphological abilities are not exempted from the typological impact of Hebrew and are able to draw upon it to some extent in their linguistic transactions such as speaking and reading.

However, this does not mean that dyslexics possess the same degree of morphological abilities as unimpaired or normal readers: recent research (Schiff & Raveh, 2007) indicates that adult dyslexic students do not make efficient use of root primes in lexical decision tasks, demonstrating their deficiency at *written* morphological processing. This task required both root and pattern identification and extraction, abilities that emerge early on in natural language acquisition (Berman, 1987, 2000, 2002), but which are essentially impaired in dyslexic individuals. In the task context, the requirement to analyze words into their components was not aided by any context clues and was certainly challenging for the dyslexic students. This was a meta-morphological task which required direct attention to the three components of the MAT in order to extract root and pattern relations from them, a task which proved extremely difficult for the adult dyslexics.

Regarding the root versus pattern errors, in writing as in speech, identifying the root is much easier than identifying the pattern. Roots carry the main lexical substance of the word, while patterns contribute specific, categorical meaning. Moreover, written roots appear as central continuous or almost-continuous clusters within the word (e.g., *masreta* 'projector' written as MSRŦHמסרטה, root underlined), or simply constitute the whole written word (e.g., *séret* 'film' written as SRŦסרט). This orthographic factor enhances the saliency of the root and its identification across stimulus set members even in the dyslexic adults. Patterns, in contrast, are not fully represented in the written Hebrew word, as they consist mostly of vowels which have scant representation in the writing system (Schiff & Ravid, 2004a) or of prefixes/suffixes which appear at the edges of the word.

The ability to analyze Hebrew words into their root and pattern components is a central process in making syntactic sense and establishing discourse coherence in a written Hebrew text which relies heavily on morphological relationships (Frost, Deutsch & Forster, 2000). Thus, these adult dyslexic students are at a disadvantage in performing academic tasks involving the analysis of morphology in reading.

Appendix 1

Structure of the MAT stimulus and response sets.

(1) MAT: Stimulus set

Orthographic format	Vertical Pair 1 related by pattern *CiCuC*	Vertical Pair 2 related by pattern *tiCCoCet*
S BWK סיבוך TSBWKT תסבוכת P ZWR פיזור ? (TPZWRT תפזורת)		
Horizontal Pair I related by Root SBK סבכ	*sibux* 'complexity	*tisboxet* 'complication' PATTERN SOURCE
Horizontal Pair II related by Root PZR פזר	*pizur* 'scatteting' ROOT SOURCE	TARGET Missing noun *tifzoret* 'piecemeal'

(2) MAT: Response set

(1) *tifzóret* — correct response sharing root $p-z-r$ with root source, and pattern *tiCCóCet* with pattern source.
(2) *pazran* 'big spender' — main root distracter, related to root source by correct root $p-z-r$, but not by correct pattern *tiCCóCet*.
(3) *tilbóšet* 'costume' — pattern distracter, related to pattern source by correct pattern *tiCCóCet* but not by correct root $p-z-r$.
(4) *mesubax* 'complicated' — secondary root distracter $s-b-x$, related to top pair
(5) *saviv* 'around' — associative distracter, related in meaning to word *pizur* 'scattering' (root source).

Appendix 2

Hebrew examples of the MAT

reader/textbook מִקְרָאָה	reading קְרִיאָה
?	the washing כְּבִיסָה

.5 laundress כּוֹבֶסֶת .4 restriction מִגְבָּלָה .3 laundry מִכְבָּסָה .2 reader (person) קוֹרֵא .1
cleanliness נִקָּיוֹן

length אֹרֶךְ	long אָרֹךְ
?	tender עָנֹג

pleasure עֹנֶג .5 elongated מָאֳרָךְ .4 pleasant נָעִים .3 delight תַּעֲנוּג .2 wall כֹּתֶל .1

References

Abu-Rabia, S. (2002). Reading in a root-based morphology language. *Journal of Research in Reading, 25*, 299–309.

Anglin, J. M. (1993). *Vocabulary Development: A Morphological Analysis*. *Monographs of the Society for Research in Child Development, 58*, 10.

Aitchison, J. (2003). *Words in the Mind: An Introduction to the Mental Lexicon* (3rd edn.). Oxford: Blackwell Publishers.

Baayen, H. (1994). Productivity in language production. *Language and Cognitive Processes, 9*, 447–469.

Bialystok, E. (1986). Factors in the growth of linguistic awareness. *Child Development, 57*, 498–510.

Ben-Dror, I., Frost, R., & Bentin, S. (1995). Orthographic representation and phonemic segmentation in skilled readers: A cross-language comparison. *Psychological Science, 6*, 176–181.

Berent, I., & Shimron, J. (1997). The representation of Hebrew words: Evidence from the obligatory contour principle. *Cognition, 64*, 39–72.

Berent, I., & Shimron, J. (2002). What is a root? In J. Shimron (Ed.), *Language processing and acquisition in languages of Semitic, root-based morphology* (pp. 201-222). Amsterdam: Benjamins.

Berman, R. A. (1985). *Acquisition of Hebrew*. In D. I. Slobin (Ed.), *Crosslinguistic study of language acquisition* (Vol. 1, pp. 255–371). Hillsdale, NJ: Erlbaum.

Berman, R. (1986). The acquisition of morphology/syntax: A crosslinguistic perspective. In P. Fletcher, & M. Garman (Eds.), *Language acquisition* (2nd ed.) (pp. 429–477). Cambridge: Cambridge University Press.

Berman, R. A. (1987). Productivity in the lexicon: new-word formation in Modern Hebrew. *Folia Linguistica, 21*, 225–254.

Berman, R. A. (2000). Children's innovative verbs vs. nouns: Structured elicitations and spontaneous coinages. In L. Menn, & N. Bernstein-Ratner (Eds.), *Methods for Studying Language Production* (pp. 69–93). Mahwah, NJ: Erlbaum.

Berman, R. A. (2002). Children's lexical innovations: Developmental perspectives on Hebrew verb structure. In J. Shimron (Ed.), *Language processing and acquisition in languages of Semitic, root-based morphology* (pp. 243–291). Amsterdam: Benjamins.

Bolozky, S. (1997). Israeli Hebrew phonology. In A.S. Kaye (Ed.), *Phonologies of Asia and Africa* (pp. 287–311). New York: Eisenbrauns.

Bolozky, S. (1999). *Measuring productivity in word formation: The case of Israeli Hebrew*. Boston: Brill.

Boudelaa, S., & Marslen-Wilson, W. (2000). Non-concatenative morphemes in Language Processing: Evidence from Modern Standard Arabic. *Proceedings of Spoken Word Access Processes* (pp. 23–26). Nijmegen: Max Planck Institute, Netherlands.

Boudelaa, S., & Marslen-Wilson, W. (2001). Morphological units in the Arabic mental lexicon. *Cognition, 81*, 65–82.

Bruck, M. (1992). Persistence of dyslexics' phonological awareness deficits. *Developmental Psychology, 28*, 874–886.

Bradley, L., & Byrant, P. (1985). *Rhyme and reason in reading and spelling*. Ann Arbor, MI: University of Michigan Press.

Carlisle, J. (1995). Morphological awareness and early reading achievement. In L.B. Feldman (Ed.), *Morphological aspects and early reading achievement*. Hillsdale, NJ: Erlbaum.

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

Carlisle, J., & Nomanbhoy, D. (1993). Phonological and morphological awareness in first graders. *Applied Psycholinguistics, 14*, 177–195.

Clark, E. V., & Berman, R. A. (1984). Structure and use in acquisition of word-formation. *Language, 60*, 542–590.

Chaudron, C. (1983). Research on metalinguistic judgments: A review of theory, methods, and results. *Language learning, 33*, 343–377.

Croft, W. (1992). *Typology and universals.* Cambridge: Cambridge University Press.

Curtin, S., Manis, F. R., & Seidenberg, M. S. (2001). Parallels between the reading and spelling deficits of two subgroups of developmental dyslexics. *Reading and Writing: An Interdisciplinary Journal, 14*, 515–547.

Deutsch, A., Frost, R., & Forster, K. I. (1998). Verbs and nouns are organized and accessed differently in the mental lexicon: Evidence from Hebrew. *Journal of Experimental Psychology: Learning Memory, and Cognition, 24*, 1238–1255.

Deutsch, A., & Frost, R. (2002). Lexical organization and lexical access in a non-concatenated morphology. In J. Shimron (Ed.), *Language processing and acquisition in languages of Semitic, root-based morphology* (pp. 165–186). Amsterdam: Benjamins.

Drews, E., & Zwitserlood, P. (1995). Morphological and orthographic similarity in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 1098–1116.

Dromi, E., Leonard, L. B., & Shteiman, M. (1993). The grammatical morphology of Hebrew-speaking children with specific language impairment: Some competing hypotheses. *Journal of Speech, Language and Hearing Research, 36*, 760–771.

Feldman, L. B. (2000). Are morphological effects disguishable from the effects of shared meaning and shared from? *Journal of Experimental Psychology: Learning, Memory and Cognition, 26*, 1431–1444.

Folz, P. W., Kintsch, W., & Landauer, T. K. (1998). The measurement of textual coherence with Latent Semantic Analysis. *Discourse Processes, 25*, 285–307.

Fowler, A. E., & Liberman, I. Y. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), Morphological aspects of language processing (pp. 189–210). Hillsdale, NJ: Erlbaum.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. E. Peterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia* (pp. 301–330). Hillsdale, NJ: Erlbaum.

Frost, R. (1995). Phonological computation and missing vowels: Mapping lexical involvement in reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 398–408.

Frost, R., Forster, K., & Deutsch, A. (1997). What we can learn from the morphology of Hebrew? A masked-priming investigation of morphological representation. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 23*, 829–856.

"JOPR–10936-9043" 2006/12/5 14:48

Frost, R., Deutsch, A., & Forster, K. I. (2000). Decomposing Morphologically Complex Words in a Nonlinear Morphology. *Journal of Experimental Psychology: Learning Memory, & Cognition, 26*, 751–765.

Gombert, J.E. (1992). *Metalinguistic development*. Translated by T. Pownall. New York: Harvester Wheatsheaf.

Joanisse, M. C., Manis, F. R., Keating, P., & Seidenberg, M. S. (2000). Language deficits in dyslexic children: Speech perception, phonology, and morphology. *Journal of Experimental Child Psychology, 77*, 30–60.

Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective of cognitive science*. Cambridge, MA: MIT Press.

Landauer, T. K., & Dumais, S. T. (1997). A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction and representation of knowledge. *Psychological Review, 104*, 211–240.

Mahony, D.L. (1994). Using sensitivity to word structure to explain variance in high school and college reading ability. *Reading and Writing, 6*, 19–44.

Marslen-Wilson, W. D. (1999) Abstractness and combination: The morphemic lexicon. In S. Garrod, & M. Pickering (Eds), *Language Processing* (pp. 101–119). NY: Psychology Press.

Mann, V. A. (1991). Are we taking to narrow a view of the conditions necessary for the development of phonological awareness? In S. Brady, & D. Shankweiler, (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 37–45). Hillsdale, NJ: Erlbaum.

Mann, V. A. (2000). An introduction to special issue on morphology and the acquisition of alphabetic writing systems. *Reading and Writing: An Interdisciplinary Journal, 12*, 143–147.

McCarthy, J. (1981). A prosodic theory of non-concatenative morphology. *Linguistic Inquiry, 12*, 373–418.

Mimouni, Z., Kehayia, E., & Jarema, G. (1998). The mental representation of singular and plural nouns in Algerian Arabic as revealed through auditory priming in agrammatic aphasia patients. *Brain and Language, 61*, 63–87.

Nelson, F. W., & Kuera, H. (1982). *Frequency analysis of English usage. Lexicon and grammar*. Boston: Houghton Mifflin.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly, 27*, 29–53.

Ravid, D. (1990). Internal structure constraints on new-word formation devices in Modern Hebrew. *Folia Linguistica, 24*, 289–346.

Ravid, D. (1995). *Language change in child and adult Hebrew: A psycholinguistic perspective.* New York: Oxford University Press.

Ravid, D. (2001). Learning to spell in Hebrew: Phonological and morphological factors. *Reading and Writing, 14*, 459–485.

Ravid, D. (2002). A developmental perspective on root perception in Hebrew and Palestinian Arabic. In J. Shimron (Ed.), *Language processing and acquisition in languages of Semitic, root-based morphology* (pp. 293–319). Amsterdam: Benjamins.

Ravid, D. (2005). Hebrew orthography and literacy. In R.M. Joshi & P.G. Aaron (Eds.), *Handbook of orthography and literacy* (pp. 339–363). Mahwah, NJ: Erlbaum.

Ravid, D., & Bar-On, A. (2001). The Semitic root in language acquisition. *GALA (Generative Approaches to Language Acquisition), 2001 Proceedings.* University of Lisbon, Cidade Universitária - Faculdade de Letras, Portugal.

Ravid, D., & A. Bar-On. (2005). Manipulating written Hebrew roots across development: The interface of semantic, phonological and orthographic factors. *Reading & Writing, 18*, 231–256.

Ravid, D., & R. Farah. (2001). Early plural lexicon of Palestinian Arabic: A longitudinal case study. *ELA 2001 Proceedings*, Institut de Sciences de l'Homme, Université Lumiere, Lyon.

Ravid, D., & Hanauer, D. (1998). A prototype theory of rhyme: Evidence from Hebrew. *Cognitive Linguistics, 9*, 79–106.

Ravid, D., & Kubi, E. (2003). What is a spelling error? The discrepancy between perception and reality. *Faits de Langue, special issue, 22*, 87–98.

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

Ravid, D., & R. Schiff. (2004). Learning to represent vowels in written Hebrew: Different factors across development. *First Language, 24*, 185–208.

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

Schreuder, R., & Baayen, R. H. (1995). Modeling morphological processing. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 131–156). Hillsdale, NJ: Erlbaum.

Schiff, R. (2002). They look similar, but they are different: reading two morphological structures of Hebrew nouns. *First Language, 22*, 305–322.

Schiff, R., & D. Ravid. (2004a). Vowel representation in written Hebrew: phonological, orthographic and morphological contexts. *Reading and Writing, 17*, 245–265.

Schiff, R., & D. Ravid. (2004b). Representing written vowels in university students with dyslexia compared with normal Hebrew readers. *Annals of Dyslexia, 54*, 39–64.

Schwarzwald, O. R. (2001). *Modern Hebrew.* München: Lincom Europa.

Schwarzwald, O. R. (2002). *Hebre morphology.* Tel Aviv: The Open University of Israel [in Hebrew].

Schiff, R., & M. Raveh. (2007). Defecient morphological processing in adult with developmental dyslexia: Another barrier to efficient word recognition? *Dyslexia*.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. E., Brady, S. A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J. M., Stuebing, K. K., Shaywitz, S. E., & Shaywitz, B. A. (1995). Cognitive profiles of reading-disabled children: Comparisons of language skills in phonology, morphology, and syntax, *Psychological Science, 6*, 149–156.

Singson, M., Mahony, D. & Mann, V. (2000). The relation between reading ability and morphological skills. *Reading and Writing: An Interdisciplinary Journal, 12*, 219–252.

Snowling, M. J. (1981). Phonemic deficits in developmental dyslexia. *Psychological Research, 43*, 219–234.

Stanovich, K. E. (1988). The right and wrong places to look for the cognitive locus of reading disability. *Annals of Dyslexia, 38*, 154–177.

Stanovich, K. E. (1989). Explaining the differences between the dyslexic and the garden variety poor reader: The phonological-core variable-difference model. *Journal of Learning Disabilities, 21*, 590–604.

Stanovich, K. E. (1991). Word recognition: Changing perspectives. In P. D. Pearson (Ed.), *Handbook of Reading Research* (Vol. 2, pp. 418–452). White Plains, NY: Longman.

Sternberg, R. (1977). Component processes in analogical reasoning. *Psychological Review, 84*, 353–378.

Valtin, R. (1984). The development of metalinguistic abilities in children learning to read and write. In J. Downing & R. Valtin (Eds.), *Language awareness and learning to read* (pp. 207–226). New York: Springer-Verlag.

Vellutino, F. (1979). *Dyslexia: Theory and research*. Cambridge, MA: MIT.