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Semantic, phonologic, and morphologic skills in reading disabled and normal children: Evidence from perception and production of spoken Hebrew

It has been frequently reported that reading acquisition is facilitated by, and perhaps depends on, the ability to segment words into smaller phonologic units (for reviews see Goswami & Bryant, 1990; Shankweiler & Liberman, 1989). Previous reports have also revealed that disabled readers have poor understanding of morphologic relations (Leong, 1989) and that reading performance in children is positively correlated with the ability to apply morphologic rules to nonsense base-words (Vogel, 1975, 1983). In addition, disabled readers have difficulty applying syntactic rules in a productive manner (Bentin, Deutsch, & Liberman, 1990; Deutsch & Bentin, in press; Fowler, 1988). Finally, recent developmental studies have shown that even in very young children, emergent literacy reflects the children's sensitivity to all these linguistic domains (e.g., Levin & Korat, 1993). Hence, the literature provides ample evidence that reading disorders are, by and large, related to poor performance in several linguistic domains (Adams, 1991; Catts, 1989; Perfetti, 1985; Stanovich, 1986). The linguistic handicap of disabled readers is evident primarily when they are required to use linguistic rules intentionally and demonstrate explicit knowledge about the internal structure of words or sentences, but it is not evident in their spontaneous speech. Consequently it has been suggested that reading disabilities are related to a deficiency in metalinguistic skills, which may be labeled "linguistic awareness" (Mattingly, 1984).

A majority of previous investigations of the relationship between linguistic skills and reading ability focus on single linguistic domains. Among these studies, phonologic awareness has been most extensively investigated (for a recent review see Bentin, 1992). Reliable correlations were found between children's ability to manipulate subword units such as onsets and rimes or single phonemes and the speed and efficiency of reading acquisition (Goswami & Bryant, 1990; Liberman, Shankweiler, Liberman, Fowler, & Fisher, 1977; Mann & Liberman, 1984; Treiman, 1985). Moreover, it has been found that phonologic abilities at kindergarten age are good predictors of reading success in the early school years (Bradley, 1989; Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980; Mann, 1984; Stanovich, Cunningham, & Cramer, 1984). The causal connection between phonologic skills and reading acquisition has been suggested by studies showing that interventions designed to improve phonologic awareness facilitated the process of reading acquisition and led to better reading performance in the early school years (Ball & Blachman, 1988, 1991; Bentin & Leshem, 1993; Blachman, 1989; Bradley & Bryant, 1983; Lundberg, Frost, & Peterson, 1988). Because phonology is obvious-

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THE ABILITY to consciously use linguistic knowledge in the semantic, phonologic, and morphologic domains was tested in fifth-grade children with reading disabilities and compared with that of normally reading age-matched controls and with a 2-years-younger group of controls matched with the reading disabled for vocabulary size. All testing involved speech. Children with reading disabilities were inferior to both control groups in their ability to assign words to semantic categories, to identify the first phoneme in spoken words, and to judge the morphologic relationship between word pairs. Their relative impairment was most conspicuous in the morphologic domain. However, the number of words produced by the reading disabled according to semantic, phonologic, or morphologic constraints was similar to that produced by the younger vocabulary-matched group, and both groups were inferior to the age-matched controls. It is concluded that the developmental reading-disabilities syndrome includes a deficit in the linguistic skills necessary for conscious application of linguistic rules in word perception and production. This linguistic impairment may explain some of the reading comprehension problems as well as the difficulty in deciphering printed words.

Habilidades semánticas, fonológicas y morfológicas de niños normales y con dificultades: Evidencia obtenida de la percepción y producción del hebreo hablado

EL PROPOSITO del presente estudio fue examinar las habilidades semánticas, fonológicas y morfológicas de niños con dificultades de lectura hablantes nativos de hebreo y comparar su desempeño con el de lectores fluídos apareados por edad o nivel de vocabulario. Todas las pruebas involucraban la lengua hablada. Los niños con dificultades de lectura fueron inferiores a los controles de ambos grupos en su habilidad para asignar las palabras a categorías semánticas, para identificar el fonema inicial en palabras habladas y para juzgar la relación morfológica entre pares de palabras. Su dificultad relativa era más notoria en el dominio morfológico. Sin embargo, el número de palabras producido por los niños con dificultades de lectura en relación a las restricciones semánticas, fonológicas o morfológicas fue similar al número producido por los lectores más jovenes apareados por nivel de vocabulario, y ambos grupos fueron inferiores a los controles apareados por edad. Se concluye que el síndrome evolutivo de dificultades de lectura incluye un déficit en las habilidades lingüísticas necesarias para la aplicación consciente de reglas lingüísticas en la producción y percepción de palabras. Este déficit lingüístico puede explicar algunos de los problemas de comprensión lectora así como la dificultad para descifrar palabras escritas.

Semantische, phonologische und morphologische Lesefähigkeiten bei behinderten und normalen Kindern: Hinweise bei der Wahrnehmung und Produktion des gesprochenen Hebräisch

DIE ABSICHT der vorliegenden Studie war es, die semantischen, phonologischen und morphologischen Fähigkeiten von hebräischsprechenden Kindern mit Leseschwierigkeiten zu untersuchen und ihre Leistungen mit denen flüssig Lesender in Rücksicht auf Alter oder Vokabular zu vergleichen. Bei jedem Test erfolgten Gespräche. Kinder mit Leseschwächen schnitten im Vergleich zu beiden Kontrollgruppen hinsichtlich ihrer Fähigkeit, Wörter semantischen Kategorien zuzuschreiben, das erste Phonem in gesprochenen Worten zu isolieren und die morphologische Beziehung zwischen Wortpaaren zu klären, schlechter ab. Die relative Verschlechterung war am auffälligsten im morphologischen Bereich. Jedenfalls war die Zahl der Wörter, die von den behinderten Lesern nach semantischen, phonologischen oder morphologischen Vorgaben gebildet wurde, ähnlich derjenigen der jüngeren, vokabelorientierten Gruppe, und beide Gruppen waren schlechter als die altersspezifischen Kontrollgruppen. Es wird gefolgert, daß das entwicklungsbedingte Leseschwierigkeitssyndrom ein Defizit auf der Ebene der bewußten Anwendung linguistischer Regeln bei der Wortwahrnehmung und -produktion bedingt. Diese linguistische Behinderung mag einige Leseverstehensprobleme wie auch Schwierigkeiten beim Entziffern von gedruckten Wörtern erklären.

読書障害児と正常な児童の意味、音韻、形態における技能：口語による ヘブライ語の認知と産出に基づく証拠

現研究の目的はヘブライ語を母国語として話す読書障害児の意味、音韻、形態における技能を調べ、その児童たちの言語運用を同じ年齢層の読みの上手な児童群及び同等の語彙力を持つ児童群の言語運用と比較することであった。テストは全てが発話を伴うものであった。読書障害児たちは、単語を意味カテゴリーにふり分ける能力、話し言葉の最初の音素を認識する能力、ペアになっている単語の形態的関係を判別する能力において、両統制群よりも劣っていた。その子供たちの相対的劣性は、形態的領域において特に顕著であった。しかし意味的、音韻的、形態的拘束を受ける読書障害児たちの発話単語数は同等の語彙力を持つ低年齢層のグループの発話単語数とほぼ同じであった。しかしその両グループとも読書障害児と同じ年齢層の統制群による発話単語数よりは劣っていた。年齢に伴って増える読書障害シンドロームの原因として、単語を認知、産出する際に言語規則を意識的に応用する言語技能が劣っているからではないかということが結論としてあげられている。こうした言語的障害が活字の単語を判読できない理由や読解におけるいくつかの問題点を解明する鍵になるかもしれない。

Compétences sémantiques, phonologiques et morphologiques chez des lecteurs ordinaires et des mauvais lecteurs : données provenant de la perception et de la production de l'hébreu parlé

CETTE ETUDE avait pour but d'examiner les compétences sémantiques, phonologiques et morphologiques d'enfants mauvais lecteurs ayant l'hébreu pour langue maternelle et de comparer leurs résultats avec ceux de lecteurs courants appariés par l'âge ou la taille du vocabulaire. La passation de tests impliquait la parole. Les enfants ayant des difficultés de lecture ont été inférieurs aux deux groupes contrôle lorsqu'il s'agissait d'assigner des mots à des catégories sémantiques, d'identifier le premier phonème de mots prononcés, et d'évaluer les relations morphologiques entre des couples de mots. Leurs difficultés relatives ont été encore plus évidentes dans le domaine morphologique. Cependant, le nombre de mots produits par les mauvais lecteurs en fonction de contraintes sémantiques, phonologiques, ou morphologiques a été semblable à ceux produits par le groupe plus jeune apparié suivant le vocabulaire, et les deux groupes ont été inférieurs aux enfants contrôle appariés par l'âge. On en a conclu que le syndrome des difficultés de lecture comporte un déficit dans les compétences linguistiques nécessaires à l'application consciente des règles linguistiques dans la perception et la production des mots. Ce défaut linguistique peut expliquer certains problèmes de compréhension de lecture aussi bien que les difficultés à déchiffrer des mots écrits.

ly related to the decoding of printed words, these studies support the view that reading relies on phonological decoding and that, at least for unskilled readers, this process demands considerable attention resources. The present study is governed by this view.

The existence of a specific semantic impairment in reading disabilities is more controversial. Inefficient lexical processes were found in real-life situations, where poor readers often demonstrate word-finding problems (Johnson & Mykelbust, 1967), and in laboratory studies, in which they demonstrate slow word-retrieval rates (Denckla & Ruddel, 1974, 1976; Wolf, 1991; Wolf & Obregon, 1992). However, it is not clear whether problems in lexical access and word retrieval are related to poor semantic processing, as suggested by Roth and Spekman (1989), or are merely an additional manifestation of phonologic processing difficulties (Catts, 1989; Liberman & Shankweiler, 1985; Murphy, Pollatsek, & Well, 1988). Therefore, understanding of the relationship between semantic competence and reading disabilities should benefit from extending the examination of semantic processing and sensitivity to semantic categories in addition to word finding and production.

Evidence relating morphologic competence to reading ability is considerably scarcer than studies of phonologic and semantic factors. Evidence of morphologic disabilities in children with a general language impairment was found in comparison with chronologically matched controls (Rubin, Patterson, & Kantor, 1991). In that study, language–learning-disabled children (i.e. children more than one standard deviation below their expected level in a series of language development tests) were significantly worse than controls in their ability to inflect and derive nonsense-word stems to fit into sentences uttered by the experimenter, and in their ability to identify and produce the base morphemes in affixed words uttered by the experimenter. However, because in the Rubin et al. (1991) study morphological competence was assessed relying only on word production, it is possible that the inferior performance in children with language impairment was not specific to the morphologic domain but rather reflected a general deficit in word retrieval. Moreover, because the language impairment of the children tested in that study was rather general, these findings cannot be directly related to reading disabilities.

Morphologic ability also distinguished among different levels of reading disability, suggesting a more direct relationship (Leong, 1989). Using sentential context, Leong found that the ability to produce the correct morphologic forms of visually presented target words correlated with the degree of reading impairment in fourth- to sixth-grade poor readers. Although these findings suggest that reading disabilities may include morphologic deficiencies, it is not clear how these deficiencies compare with other linguistic problems that reading-disabled children might have. An additional insight into the nature of the morphologic impairment may be achieved by comparing the children's ability to use morphologic rules in overtly producing words with their ability to use morphologic categories in identifying spoken words.

The last decade of psycholinguistic research has revealed that word perception and reading processes may be influenced by linguistic and orthographic specificities (e.g. Frost, Katz, & Bentin, 1987; Katz & Frost, 1992). Consequently, an additional motivation of this article was to examine whether the nature of the relationship between reading and linguistic skills, as suggested by studies in English, may be extended to Hebrew, a language that differs from English in many important aspects (Frost & Bentin, 1992).

One of the most important differences between English and Hebrew concerns the process of word formation and derivation. As a rule, Hebrew words are formed by mounting a "word-pattern"[1] of vowels and consonants on a "root" that is a skeleton of consonants. In contrast to the base word or stem in English, the Hebrew root is never a word by itself. In fact, the root is not a phonological unit but an abstract linguistic entity represented by a sequence of three (and sometimes four) phonemes (consonants). Roots convey semantic information that is in many cases transparent to the reader, but a specific meaning cannot be accessed unless a word is formed by combining the root with a particular word pattern. Nevertheless, a speaker of Hebrew can derive new words by mounting other word patterns on the same root, and can usually deduce the meaning of new words by extracting their root. For example, the root ק ש ר (the letters **K**uf **S**hin **R**eish) refers to the concept of "connection." Mounting the word pattern [- e - e -] on this root, the homographic noun קֶשֶׁר (**kesher**), that means either *knot, connection,* or *conspiracy,* is formed. Mounting a different word pattern such as [- a - a -] forms the noun קַשָּׁר (**kashar** or *radio operator).* Other words can be derived form the same root, such as תִּקְשׁוֹרֶת (**tiksho**ret—*communication*), קוֹשֵׁר (**kosher**—*conspirator* or the present masculine singular of the verb *to tie*), and many more.

The process of word formation is central to Hebrew. Consequently, the concept of a word's root and the process of word formations is formally introduced starting in the second elementary grade. Children are exposed to roots and shown how different words can be formed using the same root. The different derivatives of one root form a set of words that, in school, is often labeled a "word family" (although this term is not linguistically informative).

The semantic information conveyed by word patterns is considerably less transparent. Nevertheless, it is possible to distinguish some semantic consistency across different nominal patterns, of which the Hebrew reader (and speaker) may or may not be aware (e.g., Clark & Berman, 1984). For example, the pattern [- a- a -] is frequently used to form agents with roots that are not used to form verbs. Thus, נָגַר (**nagar**) means *carpenter*, כָּנָר (**kanar**) means *violinist*, גָּנַן (**ganan**) means *gardener*, etc. However, there are numerous exceptions, and the semantic categories of nominal word patterns are very loose. Moreover, there are word patterns that are not semantically informative. Consequently, from the psycholinguistic (as opposed to linguistic) perspective, the root probably plays a more important role than the word pattern in relating a word to its meaning.[2]

The inflectional system of the Hebrew language is richer and more complex than that of English. Verbs are inflected for person, number, gender, and tense, and adjectives are inflected for number and gender. In addition to number and gender, nouns are also inflected for relations such as locative and possessive, as well as for a specific construct state that forms compound words. However, in contrast to the derivational process in which the basic constituents (the root and the word pattern) are not words, in Hebrew, as in other languages, inflectional variants are usually formed by attaching prefixes and suffixes to real words.[3] Therefore, the psycholinguistic processes involved in understanding inflectional relationships or in inflecting verbs or nouns might be easier to grasp than derivational processes.

The significance of the root for understanding Hebrew words is also reflected in an orthography that was designed to convey to readers primarily the root information. In Hebrew the letters represent mainly consonants. The vowels are depicted by diacritical marks (points and dashes) usually presented below (sometimes within or above) the letters. These marks, however, are omitted from most reading material, and can be found only in poetry, children's literature, and religious scripts. Thus, one of the most salient characteristics of the Hebrew orthography is that it presents the reader with only partial phonological information, which in most cases is insufficient to determine unequivocally the phonological structure of the printed word. Moreover, although the diacritical marks carry mainly vowel information, in some instances they also differentiate between fricatives and stop consonants. Thus, the diacritical marks not only reduce the phonological (and consequently semantic) ambiguity of printed words, but also phonemic ambiguity. Finally, because the same root may be combined with different word (vowel) patterns to form different words, when vowel marks are absent, the same orthographic pattern (string of consonants) may denote up to seven or eight different words. Consequently, the Hebrew reader is normally exposed to semantic as well as phonological ambiguity, which can be unequivocally resolved only by the semantic and/or the syntactic context in which the ambiguous word is embedded.

Given the morphological richness of Hebrew on the one hand and the absence of sufficient phonological information in print on the other hand, one should ask how phonological skills are related to reading Hebrew and what the relative importance of phonological-morphological and semantic skills is for reading Hebrew. An informal answer to these questions is given by the fact that, despite the additional visual complexity induced by the diacritical marks, the phonological and phonemic clarity that they bear seem to be necessary for reading acquisition. Without the vowel marks, the beginning reader in Hebrew would have to rely on the holistic identification of consonant clusters and their correspondence to spoken words which, as mentioned above, is extremely ambiguous. Indeed, all the attempts to teach children to read using nonvoweled material have failed. Children in Israel start reading texts without vowels gradually, starting in Grade 3. The role of phonology in reading Hebrew has been shown also in a handful of controlled studies. For example, Bentin and Leshem (1993) found that training involving phonological skills in the kindergarten facilitated reading acquisition in school. Other studies have shown that the skilled reader of Hebrew is sensitive to the repetition of roots across different words, although the roots cannot, by definition, have independent lexical entries (Bentin & Feldman, 1990; Feldman & Bentin, 1994). Doubtless, however, more studies are necessary to elucidate the relationship between reading and different linguistic and metalinguistic skills in Hebrew.

In summary, previous studies have provided evidence that disabled readers may be handicapped in various linguistic domains, but their relative competence in each of these domains was not systematically assessed. Moreover, perception and production abilities in the different domains were not compared to a sufficient extent. The present study was designed to extend previous results in several ways. First, we intended to examine the competence of disabled readers in three domains of spoken language (phonology, morphology, and semantics) and compare it with an age-matched control group and with a second control group of younger children who were matched with the disabled readers on vocabulary level. Second, we tested processing of spoken words as well as production ability in each of the above linguistic domains. Third, our study was conducted in Hebrew,

tapping universals and language-specific characteristics of the relationship between reading and linguistic skills. We hoped that by comparing performance in different linguistic domains within the same subjects, and by comparing perception and production processes, we would be in a better position to define and elaborate the nature of the metalinguistic impairment that is specifically related to reading deficiency. To achieve this goal we designed a battery of tests that met the following two criteria: (a) to avoid intergroup differences caused simply by the obvious difference in reading ability, all tests had to be administered using oral presentation and required oral responses; (b) to compare perception and production of language, we designed a pair of similar tests in each linguistic domain, one testing processing of stimuli presented by the experimenter and the second testing production of words according to respective linguistic constraints (see below).

Method

Subjects

The reading-disabled group (RD) included 20 fifth-grade children from a population of children with severe reading problems (as diagnosed by school psychologists). All these children were enrolled in regular public schools in an upper–middle-class neighborhood but were given extra help in classes for children with learning disabilities that were integrated in those schools. Children were referred to the study by their teachers on the condition that their main learning disability was confined to reading but that they had normal WISC–R scores (IQ full scores around 100, and in no case lower than 90),[4] and no known neurological, emotional, or attention disorders. In the absence of standardized reading tests in Hebrew and conforming with our view that efficient decoding is necessary for skilled reading, the ability of each of the referred children to decipher phonological patterns was examined on a nonword reading list specifically developed for this study (see below). In addition, for the purpose of intergroup comparison and to ensure normal richness and quality of language, the children were tested on the vocabulary subtest of the WISC–R. All the children included in the reading-disabled group made errors on more than 50% of the items on the nonword reading test, but their standard score (WISC–R) on the vocabulary test was not less than 9. Hence the natural variability within the RD group was reduced by including only children who were poor decoders but had normal IQs and at least an average vocabulary score.

Two control groups of 20 subjects each were selected from the same schools. One, the chronological age control group (AC), included 20 fifth-grade subjects with adequate reading ability. Although a relationship between general intelligence and reading disability is limited to reading comprehension (Stanovich, 1991; Stanovich, Cunningham, & Feeman, 1984), and the influence that general intelligence may have on linguistic ability of disabled readers is less than clear, the children in the control groups were selected by their teachers from among children whose general intelligence was normal and within the same range as the children with reading disabilities. The second control group, the vocabulary matched control group (VC) was composed of third-grade normal readers who matched the older reading-disabled children on the vocabulary (WISC–R) raw score. Like the children in the AC group, these younger students were selected from children whose general intelligence was comparable to the reading-disabled group.

We initially intended to have a control group of normal but younger readers matched with the reading-disabled children on reading level. However, our attempts failed because we were unable to find children with such low reading scores after first grade, whereas children in first grade could not take the morphologic tests. The absence of a control group fully matched for reading skills limited our ability to infer directionality and causality from observed correlations between reading and metalinguistic deficits (Chapman & Chapman, 1985). Note, however, that the VC children were not good decoders either, as reflected by the percentage of errors in the nonword reading test. Although this percentage was considerably lower than that of the RD children, it was four times as high as that of AC children. Moreover, performance on the vocabulary test is directly related to morphologic ability, probably reflecting the flexibility of the morphologic system in Hebrew. Therefore we decided to include the younger control group in the present study. The relevant characteristics of the three groups are presented in Table 1.

Table 1 Descriptive values of subjects in each group

Group	Age (in months)	Gender (boys/girls)	Nonword reading (% of errors)	Vocabulary (raw score)
RD	124–145	14/6	74.14 (*SD* = 15.3)	24.86 (*SD* = 4.79)
AC	127–142	6/14	9.25 (*SD* = 6.6)	33.72 (*SD* = 7.63)
VC	103–114	8/12	32.23 (*SD* = 17.7)	21.00 (*SD* = 2.39)

Note: RD = Reading-Disabled Group; AC = Chronological Age Control Group; VC = Vocabulary Matched Control Group.

Materials and apparatus

Nonword reading test

The nonword reading test (see Appendix A) consisted of 24 meaningless but phonologically legal three- to four-letter strings (pseudowords), presented with vowel points.[5] The word patterns used in these pseudowords were existent morphophonemic patterns and reflected all possible combinations of letters and vowels. Each nonword was presented on a separate card (4" × 3"). A standard Hebrew font (point size 36) was used to print the stimuli on the cards. The children were instructed to read the nonwords precisely as written. Three practice trials (with feedback) ensured that the children understood the task.

Semantic categorization test

In the semantic categorization test (see Appendix B), children were presented with 4 semantic category names, each followed by 16 exemplars, 8 from the mentioned category and 8 not. The children's task was to respond as fast as they could, saying "yes" if the item was a positive exemplar of the category and "no" if it was a negative exemplar. The four semantic categories were selected among those most rich in exemplars on the basis of reported norms in Hebrew (Henick & Kaplan, 1988–1989). The categories were clothing, furniture, vegetables, and professions, presented in this fixed order. The exemplars used were the most frequent in each category. Positive and negative items were randomized in the list.

Phoneme identification test

In this test (see Appendix C), subjects were presented with 3 target phonemes, each followed by 16 frequent nouns, 8 beginning with the target phoneme (positive items) and the other 8 with different phonemes (negative items). The task was to respond as fast as possible by saying "yes" to positive items and "no" to negative items. Four of the positive and four of the negative items were one-syllable words and the other items were two-syllable words. The target phonemes used were /d/, /m/, and /x/, presented in this fixed order. Positive and negative items within a set were randomized.

Morphologic relationship judgment test

In this test (see Appendix D), two words were presented in each trial and the children were instructed to respond as fast as possible, saying "yes" if the two words were members of the same word family (morphologically related) and "no" if they were not. The test stimuli were eight frequent verbs and eight frequent nouns. Each of these stimuli was paired with four other words to form either morphologically related or morphologically unrelated pairs. There were two types of morphologically related pairs, inflections (MI) and derivations (MD), and two types of morphologically unrelated pairs. In one type of morphologically unrelated pair the target stimuli were paired with a semantically related word (SR) and in the other with a phonetically related (rhyming) word (PhR).

Verb targets. The verb targets were presented in past-tense third-person masculine singular; hence all verbs shared the same word pattern.[6] The MI target verbs were paired with the same verb, presented in the same "simple" form, but inflected for a different gender, tense, or person. The MD target verbs were paired with nouns derived from the same root as the verbs.

Noun targets. The MI target nouns were paired with a different gender- or number-inflection of the same noun. The MD targets nouns were paired with nouns that shared the same root, forming a morphologically and semantically related pair (see Bentin & Feldman, 1990).

The reaction times (RTs) were measured to the nearest millisecond from the onset of the experimenter-uttered stimulus (in each trial) to the onset of the subject's response, using an electronic counter-timer, and were logged manually by the experimenter along with the accuracy of the response. In the morphologic relationship judgment test, RT measurement began from the onset of the second word in each pair.

Semantic production test

In this test (see Appendix E), the children were instructed to come up with as many exemplars as they could of a given semantic category specified by the experimenter. Production time was limited to 30 seconds. Four categories (different from those used in the semantic categorization) were used. The categories were four-legged animals, fruits, body parts, and flowers. These categories were matched for richness of exemplars with the categories used in the semantic categorization test.

Phonologic production test

In this test (see Appendix F), the children were instructed to come up with as many words as they could starting with a phoneme specified by the experimenter. Three phonemes were used: /b/, /g/, and /sh/.[7] These phonemes were selected on the basis of existence of unpublished Hebrew norms previously established by the first author in her neuropsychological clinic. Production time was limited to 30 seconds.

Morphologic production test

Like the morphologic relationship judgment test, the production test (see Appendix G) also contained eight verbs and eight nouns. Children were presented with a target word (verb or noun) and instructed to produce as many words from the same family (morphologically related words) as possible within a limited time period (30 seconds). The instructions specifically encouraged the children to use derivational as well as inflectional relationships by providing examples of both forms.

Procedure

Each subject was tested individually in a relatively quiet room at school. There were two 30-minute testing sessions. In the first session the children were given the vocabulary and nonword reading tasks followed by the three spoken-word processing tests. During the second session a week later, the production tests were administered.

In each session the language tests were given in fixed order: semantic, phonologic, and morphologic. Each test was preceded by two practice trials to verify that the child understood the task. During the practice trials the children were given feedback and, when necessary, the task was explained again and further examples were given. No informative feedback was provided during testing.

Results

Spoken-word processing tests

The percentages of correct responses and the RTs were averaged for each subject separately in the semantic, phonologic, and morphologic tests. In the morphologic ability tests performance with verbs and nouns was similar and therefore collapsed. These data are presented in Table 2.

Reading-disabled children were less accurate and slower to respond than children in both control groups. The statistical reliability of the differences was assessed separately for accuracy and speed by mixed-model two-factor ANOVAs. The between-subjects factor was the group (RD, AC, and VC) and the within-subjects factor was the test (semantic, phonologic, morphologic). The ANOVA of the accuracy scores showed that both the main effects and the interaction were significant, $F(2,63) = 16.41$, $p<.001$, MSe = 107 for group; $F(2,126) = 40.35$, $p<.001$, MSe = 44 for test; and $F(4,126) = 5.1$, $p<.01$, MSe = 44 for interaction. Post-hoc Tukey-A comparisons revealed that, across tests, the accuracy of the RD group was significantly lower than that of the AC and VC groups, which were not significantly different from each other (HSD = 5.43, $p<.01$).

Table 2 Percentage of correct responses (positive and negative) and reaction times in milliseconds (SEM in parentheses) for each test

Group		Test		
		Semantic	Phonologic	Morphologic
RD	%	86.3 (1.5)	85.5 (2.2)	71.4 (2.1)
	RT	994 (28)	1,047 (61)	1,223 (74)
AC	%	92.6 (1.1)	92.0 (1.7)	88.8 (1.3)
	RT	920 (31)	919 (40)	923 (41)
VC	%	90.9 (1.1)	91.3 (1.3)	82.1 (2.4)
	RT	1,043 (28)	1,018 (32)	1,148 (61)

Note. SEM = standard error of the mean; RD = Reading-Disabled Group; AC = Chronological Age Control Group; VC = Vocabulary Matched Control Group; RT = reaction time.

The post-hoc comparisons clarified the nature of the interaction. The RD children were considerably less accurate than the normally reading children in all three tests; however, this difference varied across linguistic domains (Figure 1). The most conspicuous difference among groups was found in the morphologic test. In this test, accuracy decreased significantly from the AC to the VC group and was worst in the RD group ($p<.01$). In the

Figure 1 Percentage of correctly categorized items in each linguistic domain

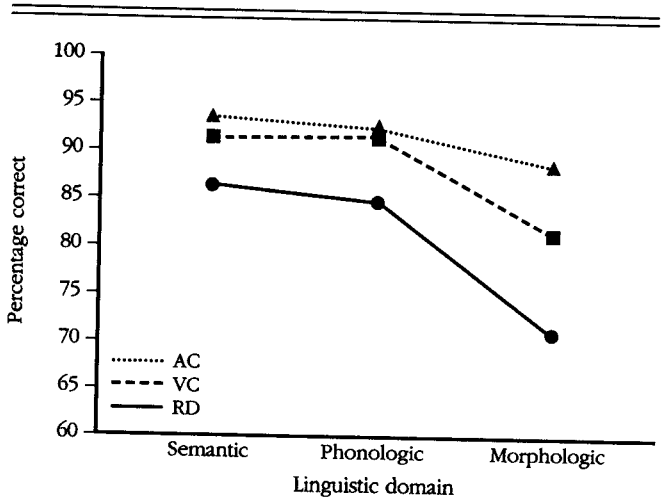


Table 3 Percentage of accuracy in the morphologic perception test for inflectional and derivational relationships (SEM in parentheses)

Group	Inflection	Derivation
RD	80.39 (3.1)	50.56 (3.2)
AC	89.48 (2.0)	71.00 (2.8)
VC	82.95 (3.9)	62.78 (4.2)

Note. SEM = standard error of the mean; RD = Reading-Disabled Group; AC = Chronological Age Control Group; VC = Vocabulary Matched Control Group.

semantic and phonologic tests, although the performance of the two control groups did not differ significantly, the reduction in the performance of RD children was statistically reliable only relative to the AC group (HSD = 6.2 $p<.05$). Note also that although a comparison of the absolute performance on each test would not be informative because the tests might vary in difficulty, it is interesting that the trends of performance within groups differed. The children in the AC group were similarly accurate on all three tests. In contrast, RD and VC children were significantly more accurate on the semantic and phonologic tests than on the morphologic test (HSD = 7.2, $p<.01$).

A comparison of the children's accuracy in judging inflectional and derivational relationships revealed reliable differences (Table 3). An ANOVA showed that across-group accuracy was better with inflections than with derivations, $F(2,63) = 6.12$, $p<.001$, MSe = 392, and that the interaction of relationship type and group was reliable, $F(2,63) = 4.23$, $p<.05$, MSe = 97.5. Post-hoc comparisons revealed that the difference between performance with inflections and with derivations was greater in the RD group (29.83%) than in either AC (18.46%) or VC (20.17%) groups, while the latter two groups did not reliably differ from each other (HSD = 10.22, $p<.01$). Although the two normally reading groups did not differ significantly, the RD group was significantly inferior to both groups with respect to derivations, whereas it did not differ significantly from the VC group with respect to inflections.

The RT data were analyzed using the same statistical model used for accuracy. An ANOVA showed that both group and test factors and the interaction between them were significant, $F(2,63) = 5.09$, $p<.01$ MSe = 108839 for group; $F(2,126) = 13.66$, $p<.001$, MSe = 18812 for test; and $F(4,126) = 4.37$, $p<.01$, MSe = 18812 for interaction. Post-hoc Tukey-A comparisons showed that RD and VC groups were equally fast, while both were slower than the AC group (HSD = 138, $p<.05$). As with accuracy, the source of the Group × Test interaction on RT was the differential effect of the tested domain in each group. RD children were significantly slower in the morphologic test than in the semantic and phonologic tests, in which speed did not differ (HSD = 148, $p<.01$). A similar pattern was observed in the VC group, except that the difference between the morphologic test and the semantic test did not reach the significance level. The AC children, on the other hand, were equally fast on all three tests.

Production tests

The number of items produced by each child was averaged separately for each test. In contrast to the pattern observed in the previous tests, the RD and VC groups were similar in the present test, while both were inferior to the AC group (Table 4).

Group × Test mixed-model ANOVA of production scores showed that both main effects were significant, $F(2,63) = 42.22$, $p<.001$, MSe = 4.88 for group factors; $F(2,126) = 74.24$, $p<.001$, MSe = 1.85 for test factors. The interaction between the two factors was not significant, $F(4,126) = 2.00$, $p>.10$, MSe = 1.85. Post-hoc Tukey-A comparisons revealed that, across tests, the number of items produced by the AC children was significantly larger than the number of items produced by the RD and VC groups, which did not differ from each other (HSD = 1.15, $p<.01$). Across groups, the number of items produced was largest in the semantic test and smallest in the phonologic tests (HSD = 0.68, $p<.01$).

Comparison of the number of inflections and derivations produced by each child in the morphologic production test revealed that inflections were significantly more frequent (Figure 2).

An ANOVA revealed that, across groups, the number of inflections produced among the morphologically related words (5.38) was significantly larger than the number of derivations (0.83), $F(1,63) = 557.17$, $p<.001$, MSe = 1.23. The interaction between type of morphologic relationship and group was significant, $F(2,63) = 4.74$, $p<.05$, MSe = 1.23, reflecting that the RD and VC groups produced almost no derivations.

Discussion

The purpose of the present study was to examine the linguistic skills of native Hebrew-speaking children with reading disabilities and compare their performance with that of fluent readers matched for age or for vocabulary size. Tests of spoken-word processing and production were used to examine the children's ability to apply linguistic knowledge explicitly in the semantic, phonologic, and morphologic domains using spoken words. In spoken-word processing, reading-disabled children per-

formed less accurately than both control groups and were slower than their age-matched controls in all three domains. This result suggests a genuine metalinguistic problem distinguishing the reading-disabled from normally reading children. In production, reading-disabled children performed as well as children 2 years younger in age and schooling but significantly worse than their age-matched controls. Hence, although the production data indicated a general linguistic handicap in reading-disabled children, these data did not rule out the possibility that part of this problem was related to the fact that the reading disabled had less experience in reading.

Before proceeding with an elaborate discussion of these results, a caveat should be considered. Although the general intelligence of all the children in this study was within the normal range and comparable across the control and reading-disabled groups, this factor could not be strictly controlled. Moreover, as reflected by the difference in the vocabulary score, the verbal IQ of the AC control group was probably higher than that of the RD group. Therefore, it is possible that some of the performance difference among groups was accounted for by general intelligence rather than being specifically related to reading disability. Note, however, that correlation between reading and general intelligence is limited to reading comprehension (Stanovich, Cunningham, & Feeman, 1984; for an extensive discussion of this issue see Stanovich, 1991). These authors as well as others (e.g., Shankweiler, Crain, Brady, & Macaruso, 1992) suggest that, although intelligence scores may account for the inferior linguistic performance of the "garden variety" type of poor readers, they are less informative in accounting for the inferior linguistic performance of children with severe reading disorders that are based on phonological handicap. Because the group of reading-disabled children examined in the present study was selected on the basis of poor ability to decipher printed nonwords while being within the limits of normal IQ scores, we believe that the inferior linguistic performance of the RD relative to the control children was related mainly to their phonological handicap rather than possible differences in general intelligence.

Spoken-word processing performance

A more detailed analysis of performance in the different spoken-word processing tests revealed that, whereas the reading-disabled children were inferior to the normal readers in all three linguistic domains, this handicap was particularly conspicuous in the processing of morphology. For example, the difference between the two age-matched groups was 6.3% in the semantic and 6.5% in the phonologic tests, but 17.4% in the morphologic test. These findings are particularly interesting because previous research points to the phonologic processes as best distinguishing between good and disabled readers.

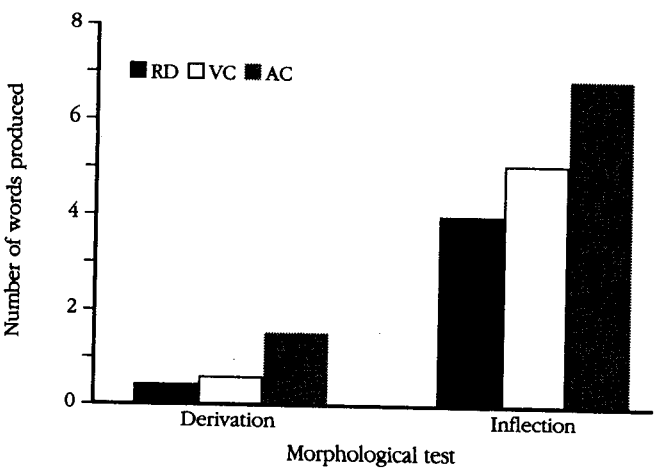
Table 4 Average number of items produced by each group in the semantic, phonologic, and morphologic tests (SEM in parentheses)

	Test		
Group	Semantic	Phonologic	Morphologic
RD	7.22 (0.2)	4.24 (0.3)	4.57 (0.3)
AC	10.47 (0.5)	7.16 (0.3)	8.37 (0.3)
VC	7.12 (0.2)	5.05 (0.3)	5.73 (0.3)

Note. SEM = standard error of the mean; RD = Reading-Disabled Group; AC = Chronological Age Control Group; VC = Vocabulary Matched Control Group.

Indeed, as in previous studies, the present results revealed a phonologic deficiency, reflected by problems in phonemic awareness, which is probably characteristic of disabled readers even in the fifth grade (Bradley & Bryant, 1985). Several investigators have suggested that phonologic impairment is not only a primary cause of reading disabilities but also a major source of other linguistic and general cognitive impediments found in reading-disabled children (e.g., Crain, 1989; Mann, Liberman, & Shankweiler, 1980; Tunmer, 1989). However, although inefficient phonologic processing might have indirectly accounted for the semantic deficiencies, it is unlikely that it was the only source of poor performance in the mor-

Figure 2 Mean number of inflections and of derivations produced by each group in the morphologic production test



phologic domain. First, phonologic performance in the reading-disabled children was considerably better than their performance in the morphologic-relationship judgment test. Second, phonologic factors that might have accounted for poor performance in the semantic and morphologic domains also should have affected vocabulary size, since the underlying assumption is that poor phonology interferes with working memory and language comprehension. However, the vocabulary size of the reading-disabled group in the present study was actually slightly larger than that of the younger group, yet their scores in the morphologic judgment test were significantly lower.

A different reason for the particularly poor performance in the morphologic domain is that the morphologic test was more difficult than the semantic and phonologic tests. This assumption is supported by the slightly reduced performance of the normally reading age-matched controls, and by the significantly lower performance of the vocabulary-matched group in the morphologic test than in the tests in the other two domains. Moreover, in contrast to phonemic awareness and semantic categorization, which are not taught explicitly, "word families"— morphologic relationships—are part of the formal curriculum in the Israeli elementary school. Therefore, although this topic is taught starting in the second grade, the lower scores of the younger children in the morphologic over the semantic and phonologic processing tests can be accounted for by the fact that they had fewer years of schooling. Similarly, the reading-disabled children might have been more impaired in the morphologic than in the other two domains because reading is a major source of information about word families.

Poor understanding of morphologic relationships might, however, also be a cause of reading disabilities. As described by Goswami and Bryant (1990, Chapter 4), the ability to use multiphonemic units may help children to decipher new words by analogy to words that have already been studied (e.g., Marsh, Desberg, & Cooper, 1977). Such a strategy might be particularly important in Hebrew, where vowel information, even if explicitly provided in print, is based on diacritics that produce additional complexity in the graphemic structure and are therefore more difficult to decipher.[8] The ability to relate new words to morphologically related familiar words should therefore facilitate reading. Furthermore, the understanding of the morphologic structure of words is probably more important for reading comprehension in Hebrew than in non-Semitic languages because Hebrew words are formed by combining two morphemes (the root and the word pattern) that are abstract and probably have no independent entries in the phonologic lexicon (Bentin & Frost, 1994; Frost & Bentin, 1992). Moreover, words related by a process of derivation may have meanings that overlap very little or not at all (Bentin & Feldman, 1990). Consequently, the morphologic relationship between Hebrew words is frequently opaque, particularly when it is created by derivation. Finally, because in Hebrew many relational and other closed-class words may be represented by single letters or letter clusters affixed to words, understanding the processes of word formation, derivation, and inflection may help the reader to parse the morphologically complex words into their constituent morphemes and facilitate lexical access.

All these considerations suggest that an impairment in the development of morphologic awareness may lead to reading disorders. The fact that the reading-disabled children were not only worse than their age-matched normally reading controls but also than younger children in judging the morphologic relationship between two words. This suggests that their morphologic impairment was not only an effect of their reading disabilities but may also have been part of its cause. However, the absence of a reading-matched control group prohibits any strong causal interpretation. Such interpretations await further investigation.

The lower achievement of the reading-disabled children in semantic categorization compared to both groups of normally reading controls is also worth noting. Developmental studies have shown that by the fifth grade both the syntagmatic and the paradigmatic semantic systems are fully developed (Berman, 1985). Moreover, previous data from our laboratory demonstrated that children in the third grade were able to use semantic category information to help identify spoken words masked by white noise (Heizler, 1988). Therefore, as revealed also by the performance of the younger controls in the present study, the relative weakness in semantic categorization observed in the reading-disabled group can hardly reflect a pure developmental factor. Reduced reading experience per se might also explain difficulties in the semantic domain because reading is an obvious source of semantic enrichment and elaboration. However, because all the exemplars used in the present study were frequent words and highly representative of their respective categories, we do not consider the reduced reading experience to be a major cause of the relatively inferior performance (although, as mentioned above, it cannot be completely ruled out by the present data). Therefore, we suggest that the fact that the reading-disabled children performed worse than the control groups in the semantic categorization task reflects a basic element of their general linguistic impairment. Whether the impairment observed in the semantic do-

main is mediated by poor phonologic processing or is independent of phonology must also await additional research.

Production performance

Two main differences distinguished the production data from the spoken-word processing data. First, in production, the reading-disabled children were not significantly worse than the younger, vocabulary matched controls. (Note, however, that a tendency in this direction was found in the phonologic and morphologic domains.) Second, in the production tests there was no difference between their achievements in the morphologic and phonologic tests.

The similarity between the performance of younger children and reading-disabled children and the fact that both groups performed worse than the age-matched controls suggest that the application of linguistic knowledge develops at a slower pace in production than in perception. Findings along these lines have been reported before, but with preschool children (de Villiers & de Villiers, 1978). These data might also suggest that the linguistic impairment of the reading-disabled children reflects a developmental lag in linguistic ability rather than a basic defect in the linguistic system (e.g., Backman, Mamen, & Ferguson, 1984). Additional support for this hypothesis can be found in the fact that significantly fewer derivatives than inflected alternatives were produced by the normally reading age-matched children. This difference makes sense if we assume that in contrast to inflection, which is more automatic, the process of derivation requires explicit knowledge about the morphologic structure of words and their possible "family" relationship.

On the other hand, a simple developmental lag hypothesis is not supported by the spoken-word processing data. There, as we mentioned above, younger controls performed as well as older normally reading children, while reading-disabled children performed worse. We are therefore inclined to believe that, although slower linguistic development may be one of the factors explaining the reduced linguistic performance of the reading-disabled children, there are other factors as well.

The similarity between the phonologic and morphologic production data suggests that, unlike in the case of spoken-word processing, in production phonologic ability does considerably limit the performance on the morphologic test. This should not be surprising because any timed word production necessarily involves word retrieval and fluency, both functions that are heavily influenced by phonologic processing. However, a phonologic disadvantage should similarly influence the production of derivatives and inflections, and the fact that it does not once again suggests the existence of more general and more complex linguistic disabilities.

In conclusion, the present study, like previous studies (e.g., Menyuk & Flood, 1981), supports a view that reading-disabled children are inferior to normal readers in several linguistic domains. The discrepancy between their apparently normal spontaneous speech and their inferior performance on tests that require the explicit use of linguistic knowledge indicates that what they lack is not ability but rather awareness and the use of that awareness in linguistic processing. We accept, therefore, previous views suggesting that reading disabilities are related to a deficient metalinguistic awareness, which might influence performance differently in different domains (see Tunmer, Pratt, & Herriman, 1984). In addition, the present study demonstrates the particularly reduced performance of reading-disabled children when they are required to use morphologic rules to associate words, a linguistic domain that has been insufficiently investigated so far. Because this particular deficiency was found in the morphologically rich and complex Hebrew language, it is not clear that morphological ability will have the same effect in other languages. Nonetheless, because trends in support of this hypothesis have already been found in English native speakers, the relationship between morphological skills and reading ability and, particularly, causal factors that may relate them requires additional investigation.

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FOOTNOTES

[1] The two major types of word patterns are verbal (called in Hebrew *bynian*) and nominal (called in Hebrew *mishkal*).

[2] For a more detailed description of pycholinguistic aspects of Hebrew morphology and a comprehensive review of studies of its influence on visual word perception, see Bentin and Frost (in press).

[3] Note, however, that due to morphophonemic and phonotactic rules, the process of affixation may also require some changes to the word pattern.

[4] We were provided by the psychological service only with group mean estimates rather than individual IQ scores, in accordance with Israeli privacy laws.

[5] Note that in the absence of vowel marks the reading of nonwords is arbitrary. Hence, vowel marks had to be included in order to determine the accuracy of phonological decoding.

[6] Words that share the same root are, by definition, morphologically related. In contrast, words that share only the word pattern are not considered morphologically related. Verbs can be conjugated in seven different forms (three active voice, two passive voice, one mixed, and one reflexive). In this study the target words were the most common form, which is a "simple" active form and, according to studies of language development in Hebrew, is completely mastered by the age of 5 to 6 years (Berman, 1985). The third-person singular of this form is usually considered the canonical form of the verb and its word pattern adds no consonants to the root.

[7] Some Hebrew phonemes may have a morphemic value and may be used as prefixes to words. For example the phoneme /b/ may be used as prefix to denote the preposition *in.* The instructions, however, were sufficiently clear, and none of the children's responses contained a preposition as the initial phoneme of the offered word.

[8] For example, lexical decisions are faster for unpointed than for pointed words (Bentin & Frost, 1987).

APPENDIX A

Pseudowords used in the nonword reading test

Pronunciation	Hebrew	Pronunciation	Hebrew
palen	פָּלֶן	tkyla	טְקִילָה
mutzya	מָצְיָע	badyf	בָּדִיף
rela	רֶלַע	shazevet	שָׁזֶוֶת
mudlar	מָדְלָר	doveh	דוֹבֶא
sabax	שָׂבָח	nylkash	נִלְכָּש
maalar	מַעֲלָר	ayutz	עָיוּץ
maltzefa	מַלְצֶפָּה	mafzysh	מַפְזִיש
shyseah	שִׁסֵּחַ	mavdetz	מַבְדֵּץ
mexaged	מְכַגֵּד	mytzham	מִצְחָם
mylkana	מִלְכָּנָה	boxet	בֹּחֶט
mafnea	מַפְנֵעַ	ralfan	רַלְפָּן
neezax	נֵאֶזָּךְ	tzador	צָדוֹר

APPENDIX B

Semantic categorization test

"There are many things in the world around us. Some of them are not connected to each other, that is, they have nothing in common—for example, 'house,' 'table,' and 'snake.' Other things are connected among themselves—that is, they have something in common. For example 'yellow,' 'green,' and 'red' are connected because they are all colors; they all belong to the 'colors' category.

"Now I will tell you the name of a group. For example, 'spices.' Is 'pepper' a spice? Good! Is 'book' a spice? Good! Here is what we will do. I will tell you first the name of a group and then several words, one after another. Each time I say a word, you should answer 'yes' as quick as you can if it represents something from the group or 'no' if it does not. Do you understand? Let us begin with the previous example: 'Spices.' "

At this point the experimenter uttered a series of words, some spices and some not, providing feedback after each response by the child. If the child understood the task, the test was presented.

The following positive (in bold) and negative exemplars were randomly presented in each category:

	Clothing	Furniture	Vegetables	Professions
1.	Paper	Pine	Tractor	**Builder**
2.	**Skirt**	Green	**Carrot**	**Gardener**
3.	Piano	**Chair**	Eucalyptus	Rain
4.	**Shirt**	Window	**Cucumber**	Sword
5.	Milk	**Table**	Cheese	**Tailor**
6.	**Trousers**	**Bed**	**Cabbage**	Milk
7.	**Undershirt**	Israel	**Tomato**	**Baker**
8.	Car	**Cupboard**	**Onion**	Rocket
9.	**Dress**	Cotton	Boat	**Cook**
10.	**Coat**	**Dresser**	**Lettuce**	Airplane
11.	Shark	**Sofa**	Whale	Oil
12.	**Sweater**	Screwdriver	Electricity	Stick
13.	**Socks**	Rooster	Robin	**Cobbler**
14.	Boat	**Armchair**	**Bell pepper**	**Barber**
15.	Hoe	Hour	Eraser	Drums
16.	Water	**Shelf**	**Zucchini**	**Physician**

APPENDIX C

Phoneme identification test

"Listen to sound /g/. Many words begin with this sound. For example גלידה ('glyda,' *ice cream*), גור ('gur,' *puppy*), and גיר ('gyr,' *chalk*). Other words do not begin with this sound. For example, חלון ('xalon,' *window*), מעגל ('maagal,' *circle*), and חג ('xag,' *holiday*). I am now going to say several words to you. Some will begin with /d/. Your task is to say 'yes' as quick as you can each time a word I say begins with /d/, and 'no' each time a word does not begin with /d/."

The same procedure was repeated with the phonemes /m/ and /x/.

The following words (phonological transcription) were randomly presented for each phoneme.

	/d/		/m/		/x/	
1.	דבש	("dvash")	מטה	("myta")	חלון	("xalon")
2.	דאר	("doar")	מלה	("myla")	חולצה	("xultza")
3.	דבק	("devek")	מזרק	("mazrek")	חידה	("xyda")
4.	דרך	("derex")	מורה	("mora")	חבל	("xevel")
5.	דב	("dov")	מין	("myn")	חג	("xag")
6.	דיר	("dyr")	מר	("mar")	חום	("xum")
7.	דם	("dam")	מים	("maym")	חור	("xor")
8.	דירה	("dyra")	מגדל	("mygdal")	חץ	("xetz")
9.	כסא	("kyseh")	גיר	("gyr")	בית	("bait")
10.	שעון	("shaon")	נר	("ner")	עמוד	("amud")
11.	גג	("gag")	צבע	("tzeva")	אח	("ax")
12.	ים	("yam")	חמור	("xamor")	מחק	("maxak")
13.	שד	("shed")	שם	("shem")	וילון	("vylon")
14.	בד	("bad")	ארון	("aron")	זר	("zer")
15.	חודש	("xodesh")	חם	("xam")	שחור	("shaxor")
16.	חדר	("xeder")	עמוד	("amud")	רך	("rax")

APPENDIX D

Morphologic relationship judgment test

"We have previously recognized words that 'go together' because they have something in common. In the present test, we will also identify words that go together except that this time I refer to words that have the same root—that is, they belong to the same word family. In each trial I will present to you two words. Your task will be to say 'yes' as quick as you can if the two words have the same root (belong to the same word family), and 'no' if they do not have the same root (belong to different word families). For example the words ראה—ראיה (*saw—sight*, respectively) have the same root, while ראה—משקפיים (*saw—spectacles*) do not share the same root (although their meaning might be connected)."

Six more examples were given before the test. The examples were four pairs of nouns and four pairs of verbs. Four of the pairs were positive examples and four negative examples. The positive examples were two derivationally related and two inflectionally related pairs. Two of the negative examples were semantically (but not morphologically) related word pairs, and two were pairs of rhyming words.

The following table presents the test words in each of the four pairing conditions separately for verbs and nouns.

Verb targets	Derivation	Inflection	Rhyme	Semantic
קָשַׁר – kashar *he tied*	קְשִׁירָה – kshyra *tying*	אֶקְשׁוֹר – ekshor *I will tie*	יָשָׁר – yashar *straight*	שְׂרוֹךְ – srox *shoelace*
שָׁכַח – shaxax *he forgot*	שִׁכְחָה – shixexa *forgetfulness*	שָׁכַחְנוּ – shaxaxnu *we forgot*	שָׁלַח – shalax *he sent*	זָכַר – zaxar *he remembered*
יָשַׁב – yashav *he sat*	תּוֹשָׁב – toshav *settler*	יָשְׁבוּ – yashvu *they were sitting*	חָשַׁב – xashav *he thought*	עָמַד – amad *he stood up*
שָׁבַר –shvar *he broke*	מִשְׁבָּר – mashber *crisis*	שׁוֹבְרִים – shovrim *we brake*	עָבַר – avar *he passed by*	פָּרַק – peirek *he demolished*
פָּגַשׁ – pagash *he met*	פְּגִישָׁה – pgisha *meeting*	נִפְגּוֹשׁ – nifgosh *we will meet with*	פָּלִישָׁה – plisha *invasion*	רָאָה – raa *he saw*
קָרָא – kara *he read*	מִקְרָאָה – mykraa *reading book*	אֶקְרָא – ekra *I will read*	בָּרָא – bara *he created*	סֵפֶר – sefer *book*
בָּכָה – baxa *he cried*	בְּכִי – bexhy *a cry*	בּוֹכִים – boxim *we cry*	לְכִי – lexi *go!*	צָחַק – tzaxak *he laughed*
דָּרַךְ – darax *he stepped on*	מַדְרִיךְ – madrix *guide*	נִדְרוֹךְ – nydrox *we will step on*	מָרַח – marax *he spread*	צָעַד – tzaad *he stepped*
צֶבַע – tzeva *color*	צַבָּע – tzaba *painter*	צְבָעִים – tzvaym *colors*	טֶבַע – teva *nature*	אָדוֹם – adom *red*
שַׁדְרָן – shadran *broadcaster* (male)	שִׁידּוּר – shydur *broadcast*	שַׁדְרָנִית – shadranyt *broadcaster* (female)	בַּדְרָן – badran *entertainer*	חֲדָשׁוֹת – hadashot *news*
מִבְרָק – myvrak *telegram*	בְּרָקִים – brakym *lightning*	מִבְרָקִים – myvrakim *telegrams*	מִבְדָּקִים – myvdakim *tests*	מִכְתָּב – myxtav *letter*
רוֹפֵא – rofeh *physician*	מַרְפֵּאָה – marpeah *clinic*	רוֹפְאִים – rofym *physicians*	אוֹפֶה – ofeh *baker*	אחוֹת – axot *nurse*
מִקְלָט – myklat *shelter*	קְלִיטָה – klyta *absorption*	מִקְלָטִים – myklatym *shelters*	מִפְלָט – myflat *refuge*	בּוּנְקֶר – bunker *fortification*
מֶלֶךְ – melex *king*	מַמְלָכָה – mamlaxa *kingdom*	מְלָכִים – malaxym *kings*	הֹלֵךְ – xelex *wonderer*	אַרְמוֹן – armon *palace*
סֶרֶט – seret *film*	מַסְרֵטָה – masreta (movie) *camera*	סְרָטִים – sratym *films*	זֶרֶת – zeret *little finger*	קוֹלְנוֹעַ – kolnoa *cinema*
חוֹלֶה – xoleh *sick/patient* (male)	מַחֲלָה – maxala *disease*	חוֹלוֹת –xolot *sick/patients* (female)	עוֹלֶה – oleh *new immigrant*	בָּרִיא – bary *healthy*

APPENDIX E
Semantic production test

"You probably remember that we previously talked about things that go together, such as 'red,' 'blue,' and 'green,' which go together because they belong to the same group—they are all colors. At that time, I gave you pairs of words and you told me if they go together or not. Now we will reverse the roles: I will tell you the name of the group, and you will tell me as many things as you can remember that belong to this group. For example, if I say 'weapons,' you should tell me as many weapons as you know, such as 'gun,' 'rifle,' etc. Let's try it. If I say 'family members,' what would you say?

"Now we will get to the task itself. As soon as I say the group name, give me the words as quick as you can." No additional feedback has been provided.

The category names were four-legged animals, fruits, body parts, and flowers.

APPENDIX F
Phonological production test

"In this test I will say a sound which is the beginning of many words. For example, the sound /d/ is the beginning of דֶלֶת—'delet' (*door*). Your task will be to give me as many words as you know that start with the sound that I say. You should do it fast without repeating words. Proper names do not count. Let's take an example. Suppose I say /s/. What could be the words that you could give me?"

After making sure that the subject understood the task, the test started, using the phonemes /b/, /g/, and /sh/.

APPENDIX G
The morphologic production test

"In this test we will return to word families. In each trial I will say one word to you. Your task will be to tell me as many words as you can that belong to the same family as the word which I say. For example, if I say to you אָכַל (*he ate*), what words would you say? You could say, for example, אוכל, מאכל, אכלתי (*dish, food,* and *I ate,* respectively). Let's see you now. If I say מנהג (*habit*), what words would you say?"

If and when the child got into a set of inflections, the experimenter would stop him or her, asking for "other words" from the same family.

The following seed words were randomly presented in this test.

	Nouns		Verbs	
1.	רַקְדָן	rakdan (*dancer*)	עָצַר	atzar (*he stopped*)
2.	מַפְתֵחַ	mafteax (*key*)	בָּנָה	bana (*he built*)
3.	מַחְשָׁבָה	maxshava (*thought*)	גָּדַל	gadal (*he grew up*)
4.	סַדְרָן	sadran (*organizer*)	בָּחַן	baxan (*he tested*)
5.	מִסְגֶרֶת	mysgeret (*frame*)	קָרַב	kerev (*he brought closer*)
6.	חִבּוּר	xybur (*connection*)	בָּחַר	baxar (*he chose*)
7.	דְלֵיקָה	dleyka (*fire*)	כָּתַב	katav (*he wrote*)
8.	מִשְׁקֶפֶת	myshkefet (*binoculars*)	רָשַׁם	rasham (*he marked*)
9.	קְפִיצָה	kfytza (*jump*)	לָמַד	lamad (*he studied*)
10.	שִׁטָפוֹן	shytafon (*flood*)	שָׁמַר	shamar (*he guarded*)