Many English-speaking children with specific language impairment have unusual difficulty with grammatical morphemes such as past tense and third-person singular verb inflections and function words such as articles. Unfortunately, the source of this difficulty is not yet clear, in part because some of the possible contributing factors are confounded in English. In the present study, alternative accounts of grammatical morpheme difficulties were evaluated using children with specific language impairment who were acquiring Hebrew. We examined the grammatical morpheme production and comprehension of 15 Hebrew-speaking children with specific language impairment, 15 normally developing compatriots matched for age and 15 normally developing children matched for mean length of utterance in words. The results provided tentative support for the notion that grammatical morphemes are less difficult for children with specific language impairment if they take the form of stressed and/or lengthened syllables and if they appear in a language in which nouns, verbs, and adjectives must be inflected. The possibility that features such as person, number, and gender are missing from the underlying grammars of these children seems less likely.

KEY WORDS: specific language impairment, morphology, inflections, Hebrew-speaking children, comprehension/production

Children with specific language impairment exhibit a significant deficit in language ability yet show normal hearing, age-appropriate scores on nonverbal tests of intelligence, and the absence of both emotional disorders and frank neurological impairment. Children meeting these criteria do not constitute a homogeneous group. However, certain profiles emerge as more common than others in these children. One such profile applies to children with specific language impairment (hereafter, SLI children) who are acquiring English. Frequently, these children show a mild to moderate deficit in a range of language areas and a more serious deficit in the use of grammatical morphemes such as the past tense -ed and third person singular -s verb inflections and function words such as the article the and auxiliary is. As a group, English-speaking SLI children make less use of such grammatical morphemes than do younger normally developing children with comparable mean utterance lengths (e.g., Bliss, 1989; Ingram, 1972; Johnston & Kamhi, 1984; Johnston & Schery, 1976; Khan & James, 1983; Steckol & Leonard, 1979).

Because the great majority of research on SLI children's morphology has focused on English-speaking children, the degree to which extraordinary problems with morphology characterize SLI children in general has not been clear. Recent work on SLI children's use of morphology in languages such as German (e.g., Clahsen, 1989; Lindner & Johnston, 1992) and Italian (e.g., Leonard, Sabbadini, Leonard, & Volterra, 1987) suggests that SLI children acquiring languages other than English may have
morphological deficits that are less severe or limited to only certain types of grammatical morphemes.

The purpose of the present investigation was to extend the study of morphology in SLI children to a language that differs significantly from English and other Indo-European languages. The focus of this study was Hebrew, a language with a rich bound morphology in which grammatical distinctions are made through prefixes, suffixes, and infixes. Given the typological differences between Hebrew and other languages that have been studied, it seemed that Hebrew-speaking SLI children might show a different profile of morphological ability.

The contribution of evidence from Hebrew goes beyond broadening the scope of descriptive data available for SLI children. Data from this language can also contribute significantly to an assessment of the alternative explanations of why morphological abilities are so limited in SLI children who are acquiring English. A brief review of these alternative accounts is provided here, followed by an explication of how data from Hebrew-speaking SLI children can clarify the issue.

Based on the work conducted to date, at least three general hypotheses have been formulated to account for English-speaking SLI children's especially poor morphology. These will be referred to as the surface hypothesis, the sparse morphology hypothesis, and the missing feature hypothesis.

**Surface Hypothesis**

According to the surface hypothesis, English-speaking SLI children's extraordinary difficulty with morphology is related to the fact that many grammatical morphemes in English take the form of word-final consonants and unstressed syllables that do not appear in positions (viz., clause-final position) in which significant lengthening occurs (Leonard, 1989, 1992; Leonard, McGregor, & Allen, 1992). Such morphemes have shorter durations than adjacent morphemes and hence may be more difficult to perceive. Because they are subject to weak syllable deletion and final consonant deletion, they are also challenging in production.

For some time, investigators of normal language development have noted that the language-learning task is made more difficult for children if the morphology possesses characteristics such as these (e.g., Gleitman, Gleitman, Landau, & Wanner, 1988; Slobin, 1985). However, the surface hypothesis addresses not only the fact that English morphology is relatively difficult, but also the fact that English-speaking SLI children have even more difficulty with morphology than younger normally developing English-speaking children with similar utterance lengths. In this hypothesis, it is assumed that SLI children are marginally capable of perceiving and producing final consonants and weak syllables but that they have a limited processing capacity that is severely taxed when such challenging forms play a morphological role. That is, when forms such as unstressed syllables and final consonants are separate morphemes, the child must perform additional operations such as discovering the grammatical functions of the forms and placing the forms in (or retrieving them from) the proper cell of a morphological paradigm. It is assumed that these additional operations render the already difficult forms vulnerable to loss. In other respects, SLI children's paradigm building is assumed to resemble that of normally developing children. For example, it is assumed that those grammatical functions that have clear semantic correlates will be hypothesized before those that do not.

**Sparse Morphology Hypothesis**

The sparse morphology hypothesis, like the surface hypothesis, assumes limited processing capacity on the part of SLI children. The account hinges on the fact that English nouns, verbs, and adjectives frequently appear as bare stems. According to this proposal, the paucity of inflections in English contributes to English-speaking SLI children's lack of attention to such morphemes in favor of more available cues, such as word order (Leonard, 1992; Rom & Leonard, 1990). That is, because of the presumably limited resources of these children, it is more adaptive to focus on those aspects of the grammar that are more likely to be present.

The sparse morphology hypothesis borrows from the proposals of investigators of cross-linguistic studies of normal language development (e.g., Berman, 1986; Slobin, 1985). For example, Berman (1986) noted that young children focus on cues that are central to their particular language, which in turn "trees them from paying time and effort-consuming attention to factors which are irrelevant or merely marginal to the language they are learning" (p. 445). In English, word order provides the critical information regarding the relations among parts of a sentence; inflections play only a minor role. Of course, the fact that the morphology of SLI children acquiring English is even more limited than that of younger normally developing compatriots with comparable mean utterance lengths requires the assumption that the effort devoted to processing the central cues of a language approaches the limit of SLI children's resources, with few resources remaining to do the work of acquiring the morphology.

It should be noted that although the paucity of inflections in a language is the determining factor in the sparse morphology hypothesis, it is assumed that free-standing grammatical morphemes (e.g., articles) are also affected. Specifically, because nouns, verbs, and adjectives frequently appear as bare stems, the child might disregard not only inflections but morphology in general, including the free-standing grammatical morphemes. Such a possibility is consistent with processing models of language learning that view grammar not as a set of autonomous components, but as a system of interacting form-function correlations (Bates & MacWhinney, 1989).

In their comparison study of English- and German-speaking SLI children, Lindner and Johnston (1992) proposed that the disadvantage of a sparse morphology relative to a rich one might be directly tied to the fact that a rich morphology is more likely to convey basic relations such as subject and object. Because a sparse morphology provides less information pertaining to these basic relations, a learner acquiring such a language will treat morphology as less essential. In
principle, such an account is not identical to the sparse morphology account described here because a language might express basic relations through free-standing grammatical morphemes (e.g., marking subject case and object case only on articles) and not employ inflections at all. However, given the correlation between the status of inflections in a language and the amount of information about basic relations conveyed by morphology in the language, we will not attempt to distinguish them in the present work.

**Missing Feature Hypothesis**

The missing feature hypothesis implicates the underlying grammars of SLI children. Gopnik (1990a, 1990b; Gopnik & Crago, 1991) has proposed that the morphological deficits of at least some of these children are the result of a grammar that lacks features needed for both morphophonemic rules and agreement relations. Thus, according to this account, there is no feature marking for number, person, tense, aspect, and gender, among others. It is recognized that English-speaking SLI children sometimes produce forms such as *cars* and *played*. However, it is assumed that these are memorized items. That is, the children learned that, say, *boys* refers to more than one boy in the same way that they learned that *men* refers to more than one man. Gopnik noted that if her position is correct, all of these features will be missing, in all manifestations of language (e.g., in comprehension as well as production).

The characteristics of Hebrew morphology seem especially appropriate for an evaluation of the above hypotheses. Hebrew nouns, verbs, and adjectives are always inflected, and thus from the standpoint of the sparse morphology hypothesis, SLI children acquiring this language should be more likely to devote their limited resources to morphology (see Berman, 1986 who makes the same observation regarding normally developing children acquiring Hebrew). Many of the inflections of Hebrew are stressed syllables and/or syllables that frequently occur in clause-final position and benefit from syllable lengthening. According to the surface hypothesis, then, they should be less of a problem than grammatical morphemes serving the same grammatical function in English. Yet there are also grammatical morphemes in Hebrew that do not possess these characteristics. Such morphemes are expected to be relatively difficult for Hebrew-speaking SLI children. Given both the obligatory nature of bound morphology in Hebrew and the fact that many of these morphemes should be less challenging in perception and production, the missing feature hypothesis can also be evaluated in a straightforward manner. According to this hypothesis, features such as person, number, gender, and tense are absent from the underlying grammars of SLI children and therefore inflections that reflect these features will be no less of a problem for SLI children acquiring Hebrew than for SLI children acquiring English.

A preliminary study of the use of morphology by SLI children learning Hebrew has already been conducted (Rom & Leonard, 1990). In that study, select grammatical morphemes noted in spontaneous speech samples from 7 Hebrew-speaking SLI (HSLI) children (age 4:4 to 5:3) (years: months) and 7 normally developing children (age 2:4 to 3:3) matched for mean length of utterance (MLU) in words were examined. Evidence consistent with both the surface and sparse morphology hypotheses was observed. Specifically, noun, verb, and adjective inflections were used by the two groups of children with similar percentages in obligatory contexts. As noted above, words in these grammatical categories must be inflected, and the forms the inflections take are stressed and/or lengthened syllables. On the other hand, differences between the groups of children (favoring the normally developing children) were seen for certain free-standing and prefixal morphemes. These are monosyllabic forms that do not receive stress or appear in clause-final position and would be predicted to be difficult by the surface hypothesis.

Nevertheless, the percentages with which these un-stressed forms were used by the HSLI children were quite high. For example, a prefix that serves as a definite marker in Hebrew was used in 84% of its obligatory contexts by the HSLI children, compared to 75% by the MLU control children. Such a percentage is considerably higher than that typically seen in the speech of English-speaking SLI children. For example, the closest English counterpart to the definite prefix of Hebrew is the definite article, a morpheme that is used in approximately 50% of its obligatory contexts by English-speaking SLI children showing the same utterance length (see Leonard et al., 1987). Such data might be taken as support for the sparse morphology hypothesis.

The Rom and Leonard (1990) study constituted only a first look at the morphology of HSLI children. Spontaneous speech samples were rather small (many under 100 utterances), and there was no attempt to ensure that grammatical morphemes were assessed in a variety of lexical contexts. For this reason, there was no means of determining the likelihood that the HSLI children's productions of grammatical morphemes were limited to highly routinized contexts—and thus the product of memorization, as permitted in the missing feature hypothesis—or whether these productions were more likely due to the availability of features in the underlying grammar. In the present study, these shortcomings were avoided by making use of detailed and carefully designed probes in which the production of grammatical morphemes could be examined in a number of lexical contexts. Furthermore, comprehension probes were included in the study to determine whether any problems observed in production might be attributable to limitations in the children's understanding of the grammatical morphemes.

**Method**

**Subjects**

A total of 45 monolingual Hebrew-speaking children participated in the study. Fifteen of the children, 13 boys and 2 girls, served as the HSLI subjects. These children had been diagnosed as language impaired and were being seen in speech clinics in the Tel Aviv area. They ranged in age from 4:1 to 5:11. The children's MLU in words based on a 100-utterance spontaneous speech sample ranged from
2.00 to 3.14. All of the children scored more than one standard deviation below the mean for their age (range: −1.2 to −4.0) on the revised version of the Guralnik Screening Test for Hebrew Speaking Preschoolers (Guralnik, Rom, & Berman, 1990). This test consists of five subtests that focus on expressive vocabulary, phonology, discourse, and the comprehension and production of syntax and morphology. All of the children passed a hearing screening at 20 dB HL at 250, 500, 1000, 2000, 4000, and 6000 Hz (re: ANSI, 1969) and showed no signs of frank neurological impairment or emotional disturbance. Their nonverbal IQs based on the Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952) ranged from 93 to 118. A test of the children’s pronunciation of singular nouns ensured that all children could produce the sounds required in the grammatical morphemes under investigation.

A second group of 15 children (hereafter, the HND-L children) served as language controls for the HSLI children. These children, 13 boys and 2 girls, ranged in age from 2:9 to 4:0. All of these children were attending preschools in the Tel Aviv area and were reported to be developing normally according to parental and teacher report. Each child scored within one standard deviation of the mean for his or her age on the Guralnik Screening Test for Hebrew Speaking Preschoolers. The children’s MLUs in words based on a 100-utterance spontaneous speech sample ranged from 1.93 to 3.35. The MLU of each child in this group was within .3 of the MLU of one of the children in the HSLI group. In addition, each HND-L child was within 1 point of that of a HSLI child on Hartman’s (1975) 5-point scale of socioeconomic status (SES) in Israel.

The third subject group (the HND-A children) consisted of 15 normally developing children who served as age controls for the HSLI children. These children ranged in age from 3:11 to 5:11. Nine of the children were boys, 6 were girls. The children were attending preschools in the Tel Aviv area. According to parental and teacher report, all of the children were developing normally. Their scores on the Guralnik Screening Test for Hebrew Speaking Preschoolers were within one standard deviation of the mean for their age. Each of these children was within 2 months of age of one of the children in the HSLI group, and within 1 point on the Hartman scale for SES.

Initial Testing

The first three sessions with each child were devoted to the administration of the language and intelligence tests and to obtaining a sample of the child’s spontaneous speech. These sessions were scheduled within 1 week of each other. The speech samples were obtained in a play session during which the experimenter—a native speaker of Hebrew—interacted with the child using a set of toys and pictures. At least 100 interpretable, nonimitative, and nondiscourse-constrained utterances were obtained from each child. The samples were recorded in a quiet room using a SONY TCM-5000EV recorder and ECM-144 electret condenser microphones. These samples were used to compute the children’s MLUs.

<table>
<thead>
<tr>
<th>TABLE 1. Present and past verb inflections for the Hebrew verb &quot;sell.&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
</tr>
<tr>
<td>Present</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Past</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Aspects of Hebrew Morphology Examined

The aspects of Hebrew morphology that were examined are briefly described here. A fuller account of Hebrew grammar can be found in Berman (1978) and Gilnert (1989). For detailed reviews of children’s acquisition of Hebrew morphology, see Berman (1985), Dromi and Berman (1982), and Levy (1988).

All Hebrew verbs and most nouns and adjectives can be described as having a root plus a pattern. The root usually consists of three consonants and conveys the core meaning, whereas the pattern is expressed through syllabic prefixes, syllabic suffixes, and/or vowel infixes inserted between the consonants of the root. For example, the root נֶכְּב has a core meaning of “kiss.” To express "kissed" in the simple, nonreciprocal sense (using third-person masculine singular as our example), the form נֶכְּבָה would be used. However, to express the reciprocal meaning "kissed one another,” the form הָנֶכֶבַּה would be selected. These two forms represent different verb patterns.

The root-plus pattern of each noun, verb, and adjective is also inflected for features such as number and gender. In the case of verbs, present tense forms are marked for number and gender, whereas past tense forms are marked for person as well as number and gender. An example of a verb from the "pa’al" pattern appears in Table 1. Although Hebrew verbs also have an infinitive form, the most basic form is taken to be the masculine singular in present tense (e.g., moixer) and the third-person masculine singular in past tense (e.g., mxar). It should be noted that although these forms are treated as basic, they are nevertheless inflected. Unlike bare stems in English (e.g., "sell"), the basic forms in Hebrew are inflected forms. For example, moixer can be only masculine singular present.

Animate and inanimate nouns are marked for number and gender. Several examples appear in Table 2. The masculine and feminine plural suffixes are -im and -ot, respectively. For many nouns, the distinction between the singular and plural forms is found only in the presence or absence of the plural suffix (e.g., xeaver-xaverim). However, for other nouns, the plural form also requires a change in the stem (e.g., perex-praxim).

1For clarity of presentation, Hebrew examples are provided in broad phonetic notation and are italicized. English glosses follow all examples.
TABLE 2. Singular and plural inflections for several Hebrew nouns.

<table>
<thead>
<tr>
<th>Word</th>
<th>Gender</th>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td>friend</td>
<td>masculine</td>
<td>xaver</td>
<td>xaverim</td>
</tr>
<tr>
<td>table</td>
<td>masculine</td>
<td>jacketan</td>
<td>jacketanot</td>
</tr>
<tr>
<td>cake</td>
<td>feminine</td>
<td>uga</td>
<td>ugot</td>
</tr>
<tr>
<td>year</td>
<td>feminine</td>
<td>jana</td>
<td>janim</td>
</tr>
</tbody>
</table>

*Irregular form requiring feminine suffix in the plural.
*Irregular form requiring masculine suffix in the plural.

As a general rule, singular nouns ending in [a] or [t] are feminine and other singular nouns are masculine. However, a number of exceptions can be found. The examples of exceptions shown in Table 2 represent a masculine singular noun that requires a feminine plural suffix (jacketan-jacketanot) and a feminine singular noun that takes a masculine plural suffix (jana-janim).

Adjectives must agree with the noun in number and gender. Several examples can be found in Table 3. It can be seen from this table that certain adjectives are modified only in word-final position to express the proper number and gender (e.g., tov-love, rek-reka), whereas others also involve a change in word-medial position (e.g., katan-ktana, sagursagura).

In addition to noun, verb, and adjective inflections, several other aspects of Hebrew morphology were of interest in the present study. One of these was the prefix ha-, which is attached to common nouns that are definite. This form is similar to the English definite article, though it differs in certain respects. First, it is attached not only to the definite noun but also to forms that modify the noun, such as adjectives. For example, the literal translation of the phrase ha-mita ha-gdola “the big bed” would be “the-bed the-big.” Second, the definite prefix does not have an indefinite counterpart as does the English definite article. For example, ra’ili kelev “I saw a dog” translates literally as “I saw dog.”

Another grammatical morpheme of interest was the definite accusative case marker et. This free-standing invariant form has no English equivalent. It precedes direct objects that are definite, including proper nouns. Thus, it appears in both ha-jeled roxets et ha-mexonit “the boy washes the car” as well as ha-jeled roxets et David “the boy washes David.” This form is not used when the direct object is indefinite, as in ha-jeled roxets mexonit “the boy washes a car.”

Grammatical Morpheme Probes

For each grammatical morpheme type to be examined, a set of probes was constructed. Noun, verb, and adjective inflections were examined in comprehension as well as production. The morphemes ha- and et were assessed in production only. All probes consisted of black and white drawings. For production, two drawings appeared on each page. The experimenter described the first picture and began a sentence describing the second picture, which the child was asked to complete. For comprehension, the child was asked to point to the drawing that corresponded to the examiner’s utterance. For the items testing comprehension of present verb inflections, each page contained the target drawing and three foils. For the items assessing comprehension of the remaining inflection types, each page contained the target drawing and one foil. The probe items for each grammatical morpheme type were presented before moving to the next grammatical morpheme type. The order of presentation was randomized across grammatical morpheme types except that all production probes were presented before the comprehension probes were introduced.

Present verb inflections. Thirty-six items were used to assess the children’s production of present tense verb inflections. The items reflected gender and/or number agreement within present tense. Two such items were ha-jeled mevagiel ve-gam ha-jaida ___ (mevagiel) “the boy cooks and the girl ___ (cooks)” and ha-jeled mittlabot ve-gam ha-jeladot ___ (mittlabot) “the boy gets dressed and the girls ___ (get dressed).” The comprehension probes consisted of 25 items. For these items, the drawings on the page depicted the same action or event but differed in the number and/or gender of the agent performing the action.

Present-past contrast. The children’s ability to produce past tense forms was assessed using 27 items. Each item involved a drawing depicting an action being performed and a drawing of the same action being completed. The experimenter described the first drawing in present tense, and began the description of the second drawing in a manner that obligated past tense. An example of one such item is kan ha-jeladim metsairim; etmol ha-jeladim ___ (tsijeru) “here the children paint; yesterday the children ___ (painted).” Only third-person singular and plural forms were examined. For each item the grammatical subjects of the two sentences (and the agents depicted in the corresponding pictures) were the same. Hence, the contrast was one of tense only. Thirty items were used to assess comprehension. As in production, the contrasts were limited to those of third-person present versus third-person past; distinctions of person, number, or gender were not tested.

Noun singular-plural contrast. Thirty-eight items were used to examine the children’s production of singular and plural noun forms. For each item, the experimenter described the first of two drawings and then began to describe the second, asking the child to complete the sentence. One such item was kan jef kapit axat ve-kan jef jalo ____ (kaplot)

TABLE 3. Gender and number inflections for several Hebrew adjectives.

<table>
<thead>
<tr>
<th>Word</th>
<th>Gender</th>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td>good</td>
<td>masculine</td>
<td>tov</td>
<td>tovim</td>
</tr>
<tr>
<td>empty</td>
<td>feminine</td>
<td>reka</td>
<td>rekot</td>
</tr>
<tr>
<td>little</td>
<td>masculine</td>
<td>katan</td>
<td>katanot</td>
</tr>
<tr>
<td>closed</td>
<td>masculine</td>
<td>sagur</td>
<td>sgurot</td>
</tr>
<tr>
<td></td>
<td>feminine</td>
<td>jana</td>
<td>janim</td>
</tr>
</tbody>
</table>
“here there is one spoon and here there are three ____ (spoons).” For half of the items, the first drawing depicted a single object and the second depicted two or three objects of the same type. For the remaining items, the drawing representing the plural preceded the drawing for the singular. Thus, half of the items assessed the children’s use of the plural when given the singular form, and half assessed their use of the singular when given the plural form. To assess the children’s comprehension, 20 items were used. For each item, the child was shown a page containing a drawing of a single object and a drawing of its plural counterpart. The child was requested to point to the singular object on 10 occasions and the plural on the remaining 10.

Adjective-noun agreement. The children’s use of adjective inflections was assessed using 20 items. As in the other production probes, the experimenter described one drawing and the child was requested to complete the experimenter’s description of the second drawing. Half of the items required the child to complete the experimenter’s sentence with an adjective in masculine singular form; in the remaining cases the child was required to supply an adjective in feminine singular form. An example of an item is ha-meil meluxelx, aval ha-xultsa ____ (nekija) “the coat (masculine) is dirty, but the shirt (feminine) is ____ (clean).” Twenty items were used to assess the children’s comprehension of adjective inflections. Two objects sharing the same attribute appeared on each page and the child was asked tare’e li . . . (e.g., gdola) “show me . . . (e.g., big—feminine).”

Definite prefix. The children’s production of the definite prefix ha- was assessed using 12 items. At the beginning of each probe item, the experimenter introduced the two characters serving as agents in the drawings. The experimenter then described the first drawing and the child was requested to describe the second drawing. An example: ze tinok ve-ze kelev. ha-tinok xote xalav ve . . . (ha-kelev ic’es etsem) “this is a baby and this is a dog. The baby drinks some milk and . . . (the dog chews on a bone).” In this example, the prefix ha- is required for “dog” because this referent had already been introduced in the discourse.

Definite accusative case marker. Finally, 10 items were used to assess the definite accusative case marker et. The items were constructed in the same way as the items for the definite prefix, although in this case the nouns requiring the morpheme served as direct objects. Half of the items used proper nouns as direct objects, and the remaining half used common nouns. An example is: ze dan ve-zo noa, aba ma’axil et dan, ve-ima mexabeket . . . (et noa) “this is Dan and this is Noah. Daddy feeds • Dan, and Mommy hugs . . . (• Noah).”

Predictions of the Hypotheses

According to the surface hypothesis, the definite prefix ha- and definite accusative case marker et should be more difficult for the HSLI children than the HND-L children because these forms are unstressed and do not receive clause-final lengthening. On the other hand, no differences between the HSLI and HND-L children were expected for the noun, verb, and adjective inflections. For the great majority of these forms, the inflection occurs in a stressed syllable. This is true for all noun plural suffixes (e.g., praxim “flowers,” sirót “boats”), most adjective inflections (e.g., sagúr “closed-masculine singular,” sgarú “closed—feminine singular”), most present verb inflections (e.g., ūtót “drinks—masculine singular,” ūtot “drinks—feminine singular,” ūtim “drink—masculine plural,” ūtot “drink—feminine plural”), and all third-person past verb inflections (e.g., histárēk “combed—masculine singular,” histarkā “combed—feminine singular,” histarkū “combed—masculine and feminine plural”). The exception is the inflection -et, which serves as the feminine singular present inflection for many verbs and the feminine singular inflection for certain adjectives. When this form is used, stress occurs on the penultimate syllable (e.g., oxel ‘e “eats—feminine singular,” meluxelx ‘et “dirty—feminine singular”). However, even in these cases the syllabic inflection -et benefits from lengthening when it appears in clause-final position, a common occurrence given that many verbs are intransitive and adjectives follow rather than precede nouns in Hebrew.

The prediction of the sparse morphology hypothesis is that the HSLI children will perform as well as the HND-L children on both free-standing morphemes and inflections. According to this hypothesis, the obligatory inflections of Hebrew will draw the HSLI children’s attention not only to inflections, but to all grammatical morphemes.

The missing feature hypothesis requires a very different prediction. Because all of the free-standing and inflectional morphemes under investigation presumably require features such as definiteness, person, number, gender, and tense—features assumed to be absent from the underlying grammars of SLI children—all of these morphemes should be more difficult for the HSLI children than for the HND-L children.

Scoring, Reliability, and Analysis

For each grammatical morpheme type assessed in the probes, a percentage was calculated by dividing the number of accurate responses by the number of scorable responses and multiplying this figure by 100. Unscorable responses were utterances that did not follow the structural constraints of the experimenter’s sentence (e.g., Experimenter: “And here there are two . . .” Child: “Is this open?”). Scorable responses followed the constraints of the experimenter’s sentence but were not always the precise lexical items anticipated. For example, both tsahov (“yellow—masculine singular”) as well as tshuhuva (“yellow—feminine singular”) would be considered scorable responses for the item assessing aduma (“red—feminine singular”). However, only tshubu would be counted as accurate because tsahov showed the wrong gender.

In the case of grammatical morpheme types taking the form of inflections, two different definitions of accuracy were adopted and were used in separate analyses. The first was the conventional definition: A response was accurate if it matched the form expected from an adult not only in inflection but also in root and pattern. Responses meeting this first definition were also subclassified according to the specific
inflection. This was important to ensure that correct productions were not limited to masculine singular forms. Because such forms can be taken as basic forms (see above), it seemed possible that they might not function as inflected forms in HSLI children's systems and therefore might be produced accurately even when no other inflections were used correctly by the children.

The second definition of accuracy required only that the person, number, gender, and tense inflection was correct, and that the word attempted by the child was recognized as the target word or a word that was equally appropriate in the context. For example, productions such as [me]lil or [va]lim for mev[alim] "they (masculine plural) cook" would be considered inaccurate according to the first definition but acceptable according to the second because the form clearly marks present masculine plural. When productions met the second but not the first definition, they were subclassified for subsequent inspection.

Finally, in some cases it was possible to identify apparent instances of overregularization. Specifically, certain noun forms used in the noun plural probes and in the adjective agreement probes had singular forms that are typically associated with one gender, but actually require a plural inflection or modifying adjective of the other gender. One such example is kos “glass,” which has a masculine form but is in fact feminine and thus requires the feminine plural inflection -ot as well as an adjective in feminine form.

Scoring of the comprehension probes was straightforward. A correct response was credited if the child pointed only to the correct drawing on the page. A response was scored as incorrect if the child pointed to the wrong drawing. Ambiguous responses and refusals to respond were noted but excluded from analysis.

Interjudge reliability was calculated on 10% of the data. Percentage of agreement among three independent scorers ranged from 92 for the production probes for the noun singular-plural contrast to 100 for all comprehension probes and the production probes for the definite prefix ha- and the definite accusative case marker et. The mean percentage of agreement across all probes was 98.

Results

Production Probes

The children’s responses on the production probes were first analyzed using the more stringent criterion of accuracy in which person, number, gender, and tense were correct as well as the root and pattern. A summary of these data appear in Table 4. The three groups’ performance was compared through between-groups analyses of variance (ANOVAs) using arcsine transformation of the percentage data. Significant ANOVAs were followed by Scheffe tests at the .05 level to determine the performance of each group relative to the performance of the others. Although the data from the HND-A children were important to establish the levels of performance expected for children of the same age as the HSLI children, the comparisons shedding the most light on the competing hypotheses were those between the HSLI and HND-L children.

A significant difference was observed for the use of present tense verb inflections, F(2, 42) = 56.01, p < .001. The HND-A children showed greater use than the HND-L children, who in turn showed greater use than the HSLI children. Because the HSLI children performed at lower levels than the HND-L children, it seemed possible that their accurate use was restricted for the most part to the basic masculine singular form. However, closer inspection revealed that this was not the case. The HSLI children’s mean percentage of accurate productions that were other than the basic form was 68.27 (SD = 6.90). The corresponding means for the HND-L children was 69.87 (SD = 6.17).

A significant difference was also seen for the present-past contrast, F(2, 42) = 16.94, p < .001. The HND-A children showed greater use than both the HND-L and HSLI children. The latter two groups did not differ. Although percentages seemed somewhat higher for the HSLI children than the HND-L children (see Table 4), the large variance seen for these two groups rendered this tendency unreliable.

The noun singular-plural contrast also produced a difference, F(2, 42) = 9.52, p < .001. Again, the HND-A children outperformed both the HND-L and HSLI children, with no difference between the latter two groups. Virtually the same pattern of results was seen for the masculine-feminine adjective inflection contrast, F(2, 42) = 20.80, p < .001.

The definite prefix ha- yielded a significant difference, F(2, 42) = 4.69, p < .025; however, the pattern across the groups was unlike that seen for the other grammatical morphemes of interest. The HND-A children showed higher percentages than the HND-L children, but the HSLI children differed from neither of the two other groups. Finally, a significant differ-
ence was seen for the definite accusative marker *et, $F(2, 42) = 9.01, p < .001$. Both the HND-A and HND-L children produced this form with higher percentages than the HSLI children. The two groups of normally developing children did not differ from one another, probably because both groups were approaching ceiling levels of performance (see Table 4).

A summary of the children's use of the verb, noun, and adjective inflections using the second definition of accuracy can be seen in Table 5. According to this definition, a response was correct if the person, number, gender, and tense inflection was correct. Other types of errors in the word were permitted, provided that the lexical item produced by the child was appropriate for the probe item. Again between-subjects ANOVAs were performed using arcsine transformations of the percentage data, and Scheffe tests were applied in cases of significant effects.

Using this second definition, the results for present tense verb inflections differed from those seen previously. As before, a significant difference was observed, $F(2, 42) = 23.95, p < .001$. However, although the HND-A children showed higher percentages than either the HND-L and HSLI children, the percentages for the HSLI children were not lower than those of the HND-L children. It can be recalled that a difference between the HSLI and HND-L groups was found when the first definition of accuracy was used with the present verb inflection data. This suggests that the two groups were probably not different in their ability to use the proper inflection. Rather, the HSLI children had more difficulty than the HND-L children with some other aspect of the verb.

This issue was explored by comparing the HSLI and HND-L children in the percentage of verb forms with correct number, gender, and tense marking but with omitted sounds or syllables that resulted in a verb pattern error. The results indicated a higher percentage of such errors by the HSLI children, $F(1, 28) = 12.32, p < .005$. The mean percentages of errors for the HSLI and HND-L children were 16.13 (SD = 7.27) and 7.27 (SD = 7.82), respectively. These findings suggest that the HSLI children's difficulty with present verb forms relative to the HND-L children were concentrated in areas of the word that affect the pattern but not the inflection marking number, gender, and tense.

The analyses for the remaining inflection types—the present-past verb contrast, $F(2, 42) = 12.40, p < .001$, the noun singular-plural contrast, $F(2, 42) = 7.30, p < .005$, and the masculine-feminine adjective inflection contrast, $F(2, 42) = 10.16, p < .001$—yielded findings that were identical to those observed using the first definition of accuracy. Specifically, a significant difference was seen for each inflection, with the HND-A children showing higher percentages than both the HND-L and HSLI children and no difference between the latter two groups.

Although no difference was seen for the present-past verb contrast, closer analysis of this inflection type seemed appropriate. As noted above, the HSLI children made less use of fully accurate present verb forms than the HND-L children, but their relative difficulty seemed to center on sounds and syllables affecting the verb pattern, not the inflection for number, gender, and tense. In the case of past forms, too, errors affecting the verb pattern can occur, although the frequency of errors of this type might be lower because of the fact that for several verb patterns the past form has fewer syllables than the corresponding present form (e.g., *mevajitim “they cook—masculine,” b[yu “they cooked”]. Accordingly, the HSLI and HND-L children were compared in terms of the percentage of productions with correct person, number, gender, and tense marking that contained an omission resulting in a verb pattern error. The difference was only marginally significant, $F(1, 26) = 3.38, p < .10$. The mean percentages for the HSLI and HND-L children were 10.93 (SD = 12.03) and 3.36 (SD = 5.39), respectively. However, considering that the two groups did not differ in their percentages of fully accurate productions (see Table 4), this marginal difference might be meaningful.

The production probe data were also examined for possible instances of overregularization. Given the composition of the probe items, overregularization of two types of inflections seemed possible—noun plural inflections and adjective inflections. Four of the probe items for noun plurals involved nouns whose singular forms are masculine but require the feminine inflection -ot in the plural. A production such as *vilonim for vilonot “curtains,” therefore, could be regarded as an overregularization. As a group, the HSLI children produced errors of this type on an average of 40% of these items. For the HND-L children, an average of 47% of the items involved this type of error. At least one error of this type was seen by 12 of the HSLI children and 13 of the HND-L children.

One of the adjective probe items required the children to choose a feminine adjective inflection to agree with the feminine noun kos “glass,” whose overt form is masculine. A production such as kos *male instead of kos melea “a full glass,” then, could represent overregularization of gender based on the form of the noun. Precisely this error was made on this item by 11 of the HSLI and 9 of the HND-L children. It is true that the two groups’ overall use of feminine adjective inflections was somewhat lower than their use of masculine adjective inflections. Therefore, there remains the possibility that some of the errors on this item were simply the result of difficulty with the feminine form rather than an instance of overregularization. However, for both groups of children this

### TABLE 5. Percentage of productions with accurate inflections.

<table>
<thead>
<tr>
<th>Morpheme type</th>
<th>HSLI</th>
<th>HND-L</th>
<th>HND-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present verb inflections</td>
<td></td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>M</td>
<td>75.53</td>
<td>78.67</td>
<td>95.73</td>
</tr>
<tr>
<td>SD</td>
<td>12.34</td>
<td>10.76</td>
<td>5.99</td>
</tr>
<tr>
<td>Present-past verb contrast</td>
<td></td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>M</td>
<td>55.60</td>
<td>29.07</td>
<td>85.33</td>
</tr>
<tr>
<td>SD</td>
<td>35.91</td>
<td>32.00</td>
<td>15.92</td>
</tr>
<tr>
<td>Singular-plural noun contrast</td>
<td></td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>M</td>
<td>75.87</td>
<td>73.60</td>
<td>91.40</td>
</tr>
<tr>
<td>SD</td>
<td>21.14</td>
<td>12.69</td>
<td>6.59</td>
</tr>
<tr>
<td>Masculine-feminine adjective contrast</td>
<td></td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>M</td>
<td>70.07</td>
<td>77.67</td>
<td>93.47</td>
</tr>
<tr>
<td>SD</td>
<td>16.55</td>
<td>15.94</td>
<td>6.09</td>
</tr>
</tbody>
</table>
particular feminine adjective item showed a lower accuracy rate than the other feminine adjective items.

**Comprehension Probes**

A summary of the children's performance on the comprehension probes can be seen in Table 6. Accuracy levels on these probes were surprisingly low. Even the HND-A children, whose mean percentages of (fully) correct productions of inflections ranged from 82.00 to 94.47, made a number of incorrect selections when responding to items involving the same inflection types.

Unlike the case for production, the comprehension task permitted a determination of the children's performance relative to chance. For the items testing the present-past verb contrast, singular-plural noun contrast, and masculine-feminine adjective contrast, the child was required to choose between the target drawing and a single foil. Hence, chance level was 50%. Binomial tests at the .05 level were used to examine the children's performance on these probes. The level of chance was only 25% for the items testing present verb inflections, as in this case each page contained the same inflection types. For example, for the three inflection types proving most difficult in comprehension—the present-past verb contrast, the noun singular-plural contrast, and the masculine-feminine adjective contrast—individual HSLI children were identified who produced these inflections with over 90% accuracy, yet scored at chance levels on the corresponding comprehension items. Even more noteworthy is the observation that 7 of the 8 HSLI children who scored at chance levels on the comprehension items for the noun singular-plural contrast actually produced overregularizations of the plural form. These findings raise the possibility that the type of knowledge required to perform well on the comprehension items is different from that required for production, even when rote learning can be ruled out as in the case of overregularization. We will return to this issue in the next section.

**Discussion**

The three hypotheses examined in this investigation were the surface hypothesis, the sparse morphology hypothesis, and the missing feature hypothesis. According to the surface hypothesis, the HSLI children should perform more poorly than the HND-L children only on the definite prefix *ha*- and the definite accusative marker *et*. The findings for production were generally consistent with these predictions, with one exception: the difference anticipated for *ha*- was not seen. The prefix *ha*- was expected to be a problem for the HSLI children because it is an unstressed syllable that does not appear in sentence positions that permit significant lengthening. The finding that this form was no more difficult for the HSLI children than for the HND-L children is at variance with the results of the preliminary study of Hebrew by Rom and Leonard (1990). Therefore, the present findings might constitute a Type II error. However, it is equally likely that the present findings reflect the true state of affairs. Sample sizes were not large in the Rom and Leonard study and the difference observed—84% for the HSLI children versus 95% for the HND-L children—was not of large magnitude.

The findings for the prefix *ha*- suggest to us that factors in addition to stress and sentence position might come into play. One possible factor can be traced to the fact that *ha*- is used with modifying adjectives as well as nouns and thus can appear in several places in the same phrase (e.g., *ha-iparon ha-adom* "the red the pencil" = "the red pencil"). This redundancy could bolster the salience of this form in the ambient language.

A second factor pertains to the metrical pattern of Hebrew words. Most words in the language show syllable-final stress. Children acquiring languages with this weak-followed-by-strong or "iambic" pattern have had greater experience perceiving and producing weak syllables that precede strong syllables and, as a result, show greater ability to produce weak syllables in these contexts than children acquiring languages with dominant strong-followed-by-weak or "trochaic" patterns such as English (Allen & Hawkins, 1980).

In contrast to the findings for *ha*-, a significant difference between the HSLI and HND-L children was observed for the remaining unstressed and unlengthened morpheme considered, the definite accusative case marker *et*. However, even
though this difference was predicted by the surface hypothesis, the percentages correct by the HSLI children were higher than expected. It seems possible that the high percentages for this morpheme, too, were brought on in part by the iambic stress bias of Hebrew. Metrical influences of this type operate across function and content word combinations as well as within multisyllabic words (see Gerken, 1991).

The production data for the four grammatical morpheme types involving inflections were in keeping with the predictions of the surface hypothesis. Because these inflections are stressed and/or frequently lengthened, they did not pose a significant perceptual or articulatory challenge for the HSLI children. In fact, evidence that might be taken as supplementary support for the surface hypothesis emerged from the findings for present verb inflections. Close analysis of the data for this grammatical morpheme type revealed that the HSLI children produced inflections marking person, gender, and tense with percentages that were as high as those seen for the HND-L children. Where the HSLI children had difficulty was in the use of syllables elsewhere in the verb that often serve to distinguish the verb pattern. Importantly, these syllables are typically unstressed and not lengthened. Thus, one possible interpretation of these data is that the HSLI children had special difficulty only with those details of present verb forms that are expressed by syllables with challenging surface characteristics.

To sum up, the production data were largely consistent with the surface account. However, at least two details in the data suggest that this hypothesis requires revision. Specifically, to accommodate the HSLI children's relatively high percentages of use of ha- and et (the difference between the HSLI and HND-L children on et notwithstanding) provisions must be made for factors such as the metrical patterns in which unstressed material appears in the language.

It seems that a more parsimonious account of the production data might come from the sparse morphology hypothesis. According to this hypothesis, SLI children can make the most of their limited resources by focusing on that aspect of the grammar that contains the most information—morphology, in the case of Hebrew. More precisely, the obligatory inflectional morphology of Hebrew will draw the children's attention to grammatical morphology in general. Thus, the HSLI children should perform like the HND-L children on all of the grammatical morphemes studied here.

The only finding that is not consistent with the predictions of the sparse morphology hypothesis is the observed difference between the two groups of children on et. However, this exception seems less problematic given the relatively high percentages with which the HSLI children used this morpheme ($M = 86.00$).

A full evaluation of the sparse morphology hypothesis requires crosslinguistic comparisons, because the hypothesis predicts not only that HSLI children will perform as well as MLU controls, but also that these children will make greater use of morphology than SLI children acquiring a language such as English, in which bare stems are permitted on nouns, verbs, and adjectives. This additional prediction is borne out by an examination of the HSLI children's productions relative to those reported in the literature for English-speaking SLI (ESLI) children. For example, in a recent study by Leonard, Bortolini, Caselli, McGregor, and Sabbadini (1992), a group of 10 ESLI children were among the subject groups. These children were similar to the HSLI children in age (3:8 to 5:7) and MLU in words (2.7 to 4.2). As in the present study, probes were used to create obligatory contexts for grammatical morpheme use. Among the grammatical morphemes examined were several that had counterparts in the present study. In each case, the ESLI children's mean percentages of use were lower than those seen for the HSLI children of the present study: (a) English articles = 52 versus Hebrew ha- = 78; (b) English noun plural inflections = 69 versus Hebrew noun plural inflections = 76; (c) English third-person singular verb inflections = 34 versus Hebrew present verb inflections = 76; and (d) English past verb inflections = 32 versus Hebrew past verb inflections = 56. Of course, caution must be taken in making comparisons of this type. As noted earlier, the definite prefix in Hebrew can be attached to adjectives as well as nouns, the noun plural inflection in Hebrew makes a gender distinction that is not made in English, and so on. Nevertheless, one cannot escape the conclusion that the HSLI children's use of morphology was more extensive than that of the ESLI children, consistent with the expectations of the hypothesis.

However, just as the surface hypothesis seems to require modification in order to accommodate all of the production findings from Hebrew, the sparse morphology account, too, needs additional provisions. Specifically, this hypothesis provides no basis for explaining the HSLI children's greater difficulty (relative to the HND-L children) with syllables affecting the verb pattern than with syllables affecting number, person, gender, and tense.

It is important to point out that although the sparse morphology hypothesis offers no rationale for expecting difficulties with verb patterns in particular, it does provide an explanation for errors of an unspecified type when SLI children are faced with a complex verb morphology as in Hebrew. This hypothesis, like the surface hypothesis, assumes a limitation in processing capacity on the part of SLI children. Given that Hebrew verbs involve distinctions in pattern as well as in person, number, gender, and tense, it is highly plausible that the multiple operations required in discovering so many grammatical functions and placing the corresponding forms in (or retrieving them from) their proper locations in paradigms could exceed these children's capacity. Therefore, a greater number of errors by these children than by MLU controls might be expected. However, in order to account for the preponderance of difficulty falling in the portion of the verb pertaining to the pattern, the hypothesis must invoke additional factors.

Clearly one way of accounting for the data would be to propose that the central factors of both the surface and sparse morphology hypotheses are operative in SLI children. Both assume limited processing capacity but an otherwise intact language-learning mechanism. In any language, grammatical morphemes with challenging surface characteristics could reduce the resources available for the operations necessary for building paradigms. However, if a language requires inflections on nouns, verbs, and adjectives, grammatical morphemes in general will receive more attention. Thus, even challenging morphemes, though still relatively
difficult, will be acquired more readily than comparable forms in a language in which morphology does not have the same status.

Of the three hypotheses examined, the observed data from production seem least consistent with the missing feature hypothesis. According to this hypothesis, features of person, number, gender, tense, case, and definiteness are absent from the underlying grammars of SLI children. Consequently, these children should have great difficulty in both producing and comprehending grammatical material that requires features of this type. It is recognized that SLI children might produce certain inflected lexical items, but that these must have been acquired through rote learning and are not the product of rules.

Given the assumptions of the missing feature hypothesis, all of the grammatical morpheme types explored here should have been more difficult for the HSLI children than for the HND-L children. Yet the two groups were very similar in their use of morphemes marking the present-past verb contrast, the singular-plural noun contrast, and the masculine-feminine adjective contrast, as well as the definite prefix. Although differences favoring the HND-L children were seen for present verb inflections when only fully accurate productions were considered, these differences disappeared when accuracy was defined in terms of the correct marking of number, gender, and tense—features presumed absent according to the hypothesis.

The evidence of overregularization in the productions of the HSLI children also makes it clear that at least some of the observed use of the grammatical morphemes could not have been attributable to rote learning. Productions such as *vilonim (correct = vilonot "curtains") are not part of the ambient language.

The data from the comprehension probes were not as informative as the production data, at least for the evaluation of the competing hypothesis. Certainly the above-chance performance seen by a number of the HSLI children adds weight to the argument that features such as number and gender were probably not missing from these children's grammars. Furthermore, the finding that the HSLI children performed at least as well as the HND-L children on all of the inflection types is consistent with the predictions of both the surface and sparse morphology hypotheses. However, before any conclusions were reached, additional investigations into SLI children's morphology were needed. One question is whether the use of unstressed syllabic morphemes that precede stressed material is facilitated in languages without dominant iambic (weak-followed-by-strong) patterns. Information of this type is necessary to determine whether the high percentages of use of ha- by the HSLI children in the present study were influenced by the iambic bias of Hebrew or, alternatively, whether these percentages were determined solely by the greater attention that these children may have placed on morphology as a result of the obligatory inflections of the language. This question might be pursued through comparisons between SLI children acquiring a language such as French and one such as Italian. Both languages use free-standing articles and are similar in their inflectional requirements but differ in their dominant metrical pattern: French has an iambic bias whereas Italian does not. Consequently, French-speaking SLI children would be expected to show higher percentages of article use than SLI children acquiring Italian.

A second question is whether relatively high percentages of errors on verb patterns are in fact attributable to SLI children's difficulty with unstressed syllables, or whether instead some other factor is responsible. For example, it is

---

2This argument might seem to give hope to the missing feature hypothesis, in that it appears to suggest that correct production can occur without features such as number, gender, and the like. However, apart from the likelihood that the differing role of features in comprehension and production is one of degree, the missing feature hypothesis would be in even deeper trouble if such an interpretation were adopted. Even fewer HND-L children scored above chance levels on the comprehension probes. Thus, it would have to be concluded that these children, too, functioned without features in their underlying grammars. If MLU controls were not different in this respect from SLI children, the oft-cited finding of greater use of morphology by MLU controls than by SLI children would then require an entirely different explanation.
plausible that these errors are due to a separate problem with the types of notions that are expressed in verb pattern distinctions, such as causation, reciprocity, and reflexivity.

Finally, more research is needed on the question of limited processing capacity. As discussed in this paper, SLI children's processing capacity could be taxed by (a) adding difficult perceptual/articulatory material to the process of morphological paradigm building; (b) reducing the availability of morphology in the language, thereby enabling other aspects of the grammar to compete for the child's limited resources; or (c) making the paradigms themselves highly complex. To begin to sort out these possibilities, crosslinguistic comparisons of SLI children might be made in which two of these factors are controlled thus permitting examination of the contribution of the third. Research of this type might provide important information about the proper way to characterize limited processing capacity in SLI children.

Acknowledgments

The authors wish to thank Shlomit Mor, Lisa Savila, and Sarah Zadunaisky for their extraordinary help in subject identification, data collection, transcription, and data analysis. This research was supported by NIH research grant DC00458.

References


Received October 21, 1992
Accepted February 22, 1993

Contact author: Esther Dromi, PhD, School of Education, Tel Aviv University, P.O.B. 39040, 69978 Tel Aviv, Israel.
The Grammatical Morphology of Hebrew-Speaking Children With Specific Language Impairment: Some Competing Hypotheses

Esther Dromi, Laurence B. Leonard, and Michal Shteiman

J Speech Hear Res 1993;36:760-771

This information is current as of June 16, 2011

This article, along with updated information and services, is located on the World Wide Web at:
http://jslhr.asha.org/cgi/content/abstract/36/4/760