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Morphological Abilities of Hebrew-Speaking Adolescents With Williams Syndrome

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In recent years research has focused on the exact nature of the linguistic skills that individuals with Williams syndrome (WS) exhibit. This work has resulted in controversial positions, with an increasing number of studies casting doubt on previous claims of superior linguistic competence for individuals with WS. This study investigated morphosyntactic knowledge in Hebrew-speaking adolescents with WS. The participants' performance was compared to 2 groups of typically developing mental age-matched controls. Participants and controls were tested on experimental tasks designed to investigate knowledge of morphology. The findings suggest that individuals with WS have good control over the basic consonantal root structure of Hebrew words. However, rather poor performance was evident on other morphological paradigms. We conclude that there is little evidence from Hebrew to support a selective preservation of grammatical competence in individuals with WS.

The cognitive profile of individuals with Williams syndrome (WS) has been characteristically described as composed of spared auditory short-term memory and spared linguistic and face recognition abilities together with serious deficits in number skills,

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visuospatial cognition, motor behavior, planning, and problem-solving (Bellugi, Marks, Bihrle, & Sabo, 1993; Bellugi, Mills, Jernigan, Hickock, & Galaburda, 1999; Bellugi, Wang, & Jernigan, 1994; Gosch, Städing, & Pankau, 1994; Mervis, Morris, Bertrand, & Robinson, 1999; Udwin & Yule, 1991; Udwin, Yule, & Marin, 1987). Studies of language in individuals with WS in the 1980s and early 1990s often presented WS as the prime example within developmental disorders of the dissociation of language from other cognitive skills, particularly from visuomotor skills.

In recent years research has focused on the exact nature of the linguistic competence that individuals with WS exhibit. This work has resulted in controversial positions, with an increasing number of studies casting doubt on the claim of superior linguistic performance of individuals with WS. At the focus of this debate are studies of morphosyntax and lexical semantics. In the review of the literature that follows we focus on the former because this is the area of linguistic knowledge to which studies of Hebrew are uniquely relevant.

In her seminal work on the cognitive profile of adolescents and adults with WS, Bellugi et al. (1994) argued that the WS linguistic profile shows a sparing of syntax both in comprehension and in production, which extends to tests of metalinguistic abilities. Morphological markers are generally used correctly, including markers for tense and aspect, as well as auxiliaries and articles. In most of these studies, the achievements of participants with WS were compared to those of individuals with Down syndrome. Udwin and Dennis (1995) agreed with the view expressed by Bellugi and colleagues. They, too, concluded that mature individuals with WS have an unusual command of language: their comprehension is usually far more limited than their expressive language, which tends to be grammatically correct, complex, and fluent at a superficial level, but verbose and pseudo-mature (but see Udwin & Yule, 1991).

Investigations of language in individuals with WS that have used standardized tests consistently yield an advantage of performance on verbal tasks over performance on visuomotor tasks. However, achievement on verbal tasks is not superior in any sense. Although performance varies considerably among individuals with WS, it typically does not reach chronological age (CA) level. Auditory memory more often reaches the expected CA level.

Mervis et al. (1999) studied the cognitive profile of individuals with WS, children as well as adults. They concluded that the language abilities of individuals with WS as measured on standardized tests are significantly delayed relative to CA controls. Delay was evident on receptive vocabulary, receptive grammar, semantic fluency, and syntactic measures (see also Karmiloff-Smith et al., 1997). However, syntactic abilities as well as mean length of utterance (MLU) were at the expected level for mental age (MA). Furthermore, whereas achievements on visuospatial tasks were significantly lower than scores on verbal tasks, performance on these two types of tasks was strongly correlated. The existence of such correlations suggests that language in individuals with WS is not independent of other cognitive skills.

Jarrold, Baddeley, and Hewes (1998) reported a large discrepancy between verbal and nonverbal abilities seen in the group of WS participants they studied as a whole, as measured by MAs obtained from standardized tests. However, they argued that this discrepancy is a function of the performance of only some of the participants in the study. The authors suggested that these results may be explained as a function of verbal ability developing at a faster rate than nonverbal ability in WS. Larger discrepancies between verbal and nonverbal abilities are thus expected in adolescents than, for example, in young children. Udwin and Yule (1990) reached a similar conclusion. They observed that one third of the group they studied produced significantly more speech output, with more complex syntactic structure, more social phrases, and more clichés than seen for the rest of the group.

Studies of Italian-speaking individuals with WS are of particular relevance to this work because Italian, like Hebrew, has complex morphology, although these languages are typologically different. Volterra, Capirci, Pezzini, Sabbadini, and Vicari (1996) investigated 17 children and adolescents with WS, with CA ranging from 4 years, 10 months (4:10) to 15:3. MA ranged from 3:8 to 6:8 and IQ from 38 to 90. Typically developing (TD) children whose CAs corresponded to the MA of the individuals with WS served as controls. Results showed that the two groups did not differ on tests of lexical comprehension or semantic fluency or on MLU. However, the participants with WS obtained significantly lower scores than the TD controls on receptive syntax, vocabulary, and sentence repetition. When individual scores were considered, most of the participants with WS performed below the lowest levels achieved by the TD controls on all of the these tasks.

Recent investigations of the cognitive profiles of Italian children with WS lend further support to these findings. Studies show impaired visuospatial abilities along with linguistic performance that did not exceed MA expectations. Linguistic knowledge was characterized by very good phonological abilities along with specific deficiencies in syntax as well as in lexical semantics (Volterra et al., 1996).

Along with assessments on standardized tests, individuals with WS have been tested on experimental, nonstandardized tasks. Such tasks are particularly important when specific claims concerning preserved linguistic abilities are at stake. Karmiloff-Smith et al. (1998) studied a group of individuals with WS, of CA 14:9 to 34:8, with a mean Performance IQ of 58 and a mean Verbal IQ of 71. Participants were given online tasks of monitoring for target words and an offline picture-matching task. Results from the online tasks show sensitivity to the violation of auxiliary markers and phrase structure rules, but significantly less sensitivity to violations of subcategorization rules. Performance on the offline task was overall poorer than that of the controls.

Testing individuals with WS on online tasks is important because these offer ways of dealing with two major difficulties that plague the other two most common methods of investigation of linguistic knowledge, analysis of naturalistic productions and explicit testing. Whereas the first provides limited data, which may be biased in crucial ways, the second requires a level of awareness that is likely to complicate the task for individuals with cognitive impairments. The results from the online task are therefore particularly interesting and informative. However, the choice of control group in this particular study—18 normal adults ranging in age between 19 and 29 years—is problematic because neither MA nor CA served as matching criterion.

Few studies have been concerned with the early phases of language development in children with WS. Capirci, Sabbadini, and Volterra (1996) reported on a longitudinal follow-up of an Italian girl with WS. Observations of this child began when she had about 20 words and no syntax. The study reported similarities between the acquisitional course followed by this child and the developmental course observed in TD children. However, some differences were noted as well. In particular, although the child with WS had good vocabulary and proficient syntax, she made agreement errors and errors of pronominalization not documented for TD Italian children. By the age of 4:10, the child's cognitive profile as measured on standardized tests was typical of WS, with linguistic abilities better than visuospatial ones, although the latter were less impaired than often seen in children with WS.

Levy (2002) followed 2 Hebrew-speaking children with WS from the beginning of two-word combinations, when their MLU was 1.8, until MLU reached 2.8, 18 months later. The children's progress on 12 different linguistic variables was documented. The course of development was compared to the course observed in TD children of similar MLU. The linguistic profile of the children with WS differed from that of the controls in every phase observed. Interestingly, this finding is very different from what has been observed in children with other neurodevelopmental disorders (Levy, Tennebaum, & Ornoy, 2000). In the latter, development in the early phases, when MLU barely reached 3.00, was very similar to that observed in TD children. Thus, similar to the early development of the Italian child studied by Capirci et al. (1996), the Hebrew-speaking children seem to differ in interesting ways from what has been observed in TD children.

Pezzini, Vicari, Volterra, Milani, and Ossella (1999) argued that individual profiles of children with WS vary considerably and thus one cannot argue that there exists a single neuropsychological profile of individuals with this syndrome. The Italian study argues against the findings of Frangiskakis et al. (1996) and Mervis et al. (1999), who reported a characteristic cognitive profile for individuals with WS. In a recent study of the cognitive profile of Hebrew-speaking adolescents with WS, we were able to replicate the results of Frangiskakis et al. (1996) and Mervis et al. (1999), both for the group overall as well as in the individual profiles (Levy & Bechar, in press). There was no evidence in the Hebrew data for the variability seen in the Italian group.

Three recent studies (Clahsen & Almazan, 1998; Clahsen & Temple, 2003; Karmiloff-Smith et al., 1997) are of particular relevance to the work on Hebrew reported here. These studies focused on morphology and morphosyntax in children with WS. Karmiloff-Smith et al. (1997) studied gender agreement between article and noun in French-speaking adolescents and young adults with WS. Whereas the participants performed well with familiar nouns, they seemed unable to apply gender agreement between the definite article and novel nouns that were presented to them. MA controls, however, performed well on this task. Karmiloff-Smith et al. (1997) concluded that knowledge of morphosyntactic rules is impaired in WS and suggested that the impressive spontaneous language of individuals with WS is a consequence of their good auditory memory.

The findings of Clahsen and Almazan (1998) and Clahsen and Temple (2003) are in direct opposition to those of Karmiloff-Smith et al. (1997). Past tense formation, noun plurals, and compounding were investigated in 4 English-speaking children with WS. Results showed that children with WS overregularize the past tense –ed and the plural –s significantly more often than MA controls; knowledge of the irregular past and the irregular plural forms was relatively poor. The children overapplied the –s plural to the internal nominal elements within lexical compounds (yielding, for example, the ungrammatical compound "*rats-eater" instead of "rat-eaters"). Similarly, the children overapplied the regular comparative affix –er to cases in which a comparative "more" was required. Clahsen and colleagues interpreted these findings as evidence of a preserved grammatical rule system along with considerable deficits in lexical knowledge such as is implicated in knowledge of irregular forms.

In this work we investigated knowledge of Hebrew morphology in 10 adolescents with WS. Of particular relevance to the current debate concerning the nature of the linguistic knowledge of individuals with WS is the participants' performance on tasks that involve strictly formal morphological systems. If indeed the grammatical rule system is preserved in WS, as argued by Clahsen and his colleagues, then performance on those tasks should reflect such knowledge. One of the tasks that was used to this end was a replication of Karmiloff-Smith et al.'s (1997) study of gender agreement with minor modifications due to the differences between French and Hebrew. As for knowledge of other morphological systems in which change of forms affects meaning, those may be more directly affected by the participants' cognitive impairments and thus less informative with respect to their grammatical competence.

BRIEF DESCRIPTION OF HEBREW MORPHOLOGY AND RELATED ACQUISITIONAL FACTS

Hebrew has the characteristics of Semitic languages, that is, words are composed of consonantal roots cast in vocalic word patterns. The roots are usually tri-consonantal, whereas the patterns are in the form of vocalic infixes, prefixes, and suffixes. There are seven verb patterns (*binyanim*) and about three dozen noun patterns (*mishkalim*).

All verbs are analyzable into root + pattern. With respect to nouns, however, this generalization is only partial because some nouns do not have a recognizable root.

It is generally the case in Hebrew that the roots convey core meanings, whereas *binyanim* and *mishkalim* are essentially derivational paradigms that may partially introduce meaning modulations. However, although the formal paradigms are highly systematic, the semantics that they convey is only partially predictable from their forms. For example, the verb patterns (*binyanim*) may serve to express a set of predicate relations such as transitivity, reciprocity, reflexivity, passive, and causative. However, the same function may be expressed by more than one pattern, whereas the same pattern may serve to express more than one meaning or be "basic" for a given root (see examples that follow). Derivational paradigms for nouns are often strictly formal and do not convey meanings at all although some noun patterns do have a productive semantics. Thus, one can consider well-formedness of verbs and nouns that is independent of the meanings that these formal manipulations may convey. Hebrew has a rich inflectional morphology. Generally, verbs are inflected for tense, number, person, and gender.

The following are examples of verbs and nouns from the root *G-D-L* (root consonants are in capitals; verbs are in third person, masculine, singular, past tense; nouns are in singular form):

1. *GaDaL*, "grew," intransitive verb
2. *GiDeL*, "*grew*," transitive verb
3. *GuDaL*, "was grown," passive verb
4. *hiGDiL*, "made bigger," active causative verb
5. *huGDaL*, "made bigger," passive causative verb
6. *GDiLa*, "growing up," noun
7. *GiDuL*, "tumor, growth," noun
8. *GaDLut*, "grandeur," noun
9. *haGDaLa*, "enlargement," noun
10. *miGDaL*, "tower," noun

Berman (1994) argued that early verb use is rote-learned and thus item-based. It is characterized by one verb form per root. Once the child begins to vary verb forms, there will be many more forms for each root, for roots will occur in different *binyanim* bearing different inflectional endings. The expectation is, therefore, that with development, there will be an increase in the proportion of verb forms to verb roots (Levy, 1996).

Hebrew-speaking children start out with semantically unanalyzed forms of verbs, yet at the same period they can effectively control the morphological manipulations of the various root + pattern combinations. Two-year-old Hebrew speakers differentiate between the consonantal roots and the vocalic word patterns, although they are still unable to use those to modulate meaning (Levy, 1988a). For quite some time children continue to use a rich variety of verb forms in morphosyntactically appropriate contexts, not knowing that these formal manipulations may be systematically used to achieve modulations of meanings. It is only around age 4 years, a long time after they have been using most verb patterns productively, that children's errors indicate that they begin to appreciate the semantics of the system (Berman, 1985, 1994).

Hebrew nouns are classified for gender and this classification determines forms of agreement. Although gender is correlated with noun endings, the correlation is not perfect. Typically, nouns ending with a stressed /***a***/ or in /***t***/ are feminine. Such nouns take the suffix /***-ot***/ for plural. All other nouns are in general masculine and take /***-im***/ for plural. Importantly, however, although the system is rather regular, exceptions do exist. Thus, not all feminine nouns take /***-ot***/ for plural and similarly not all masculine nouns take /***-im***/ for plural. Because ultimately gender is a lexical property of nouns, despite the high correlation between morphological endings and gender, the infallible clue to noun gender is syntactic agreement, which is marked on adjectives and on verbs.

The following are examples of noun + adjective combinations in Hebrew in the singular and in the plural. Examples 1 to 4 are of cases of concordant combinations, in which the ending on the noun matches the agreement marker on the adjective, whereas examples 5 to 10 are of discordant cases, in which there is a mismatch between the ending on the noun and the agreement marker on the adjective. These examples are important because they illustrate the paradigm that was used to replicate Karmiloff-Smith et al.'s (1997) study of gender agreement in French:

1. *agala-**a*** + *ktan-**a***
   cart (fem.) + little (fem.): small cart
2. *agal-**ot*** + *ktan-**ot***
   carts (fem.) + little (fem. pl.): small carts
3. *bakbuk* + *katan*
   bottle (masc.) + small (msc.): small bottle
4. *bakbuk-**im*** + *ktan-**im***
   bottles (masc.) + little (masc. pl.): small bottles
5. *zipor* + *levan-**a***
   bird (fem.) + white (fem): white bird
6. *zipor-**im*** + *levan-**ot***
   birds (fem.) + white (fem. pl.): white birds
7. *beic-**a*** + *kash-**a***
   egg (fem.) + hard (fem.): hard-boiled egg
8. *beic-**im*** + *kash-**ot***
   eggs (fem.) + hard (fem. pl.): hard-boiled eggs
9. *kir* + *shaxor*
   wall (masc.) + black (masc.): black wall

10. *kir-**ot*** + *shxor-**im***
    walls (masc.) + black (masc. pl.): black walls

Finally, notice that feminine nouns may be derived from masculine nouns by adding one of the familiar feminine endings, as in the following examples:

11. *yeled* → *yald-**a***
    boy girl
12. *tarnegol* → *tarnegol-**et***
    rooster hen

Previous studies of the acquisition of gender in Hebrew have shown that children master the formal–morphological parts of this system relatively early (Berman & Armon-Lotem, 1996; Levy, 1983, 1988b). Thus, by age 3 years, errors of linguistic gender on inanimate nouns as well as errors of gender agreement across noun phrase and sentence constituents are infrequent. In cases of animate nouns, in which the linguistic gender is determined by the semantic notion of gender, learning is a more protracted process. These findings hold cross-linguistically for all languages studied so far (Levy, 1988b; Mulford & Morgan, 1983; Smoczynska, 1985).

In sum, Hebrew has a very rich morphology with a few paradigms that are strictly formal, whereas others serve to introduce meaning modulations. There is considerable knowledge concerning the acquisition of these different systems in TD children. Data from Hebrew-speaking individuals with WS may therefore provide additional insights into the nature of linguistic abilities of people with WS.

METHOD

Participants

Ten adolescents (6 girls, 4 boys) with a firm genetic diagnosis of WS who are monolingual, native speakers of Hebrew participated in the study. The participants were living at home with their families and were in good health. They were recruited through the Israeli Williams Syndrome Association. All were given the full Wechsler Intelligence Scale for Children–Revised. Mental ages were derived from performance on this test. Table 1 provides information on the participants' CA and IQ. The participants were similar in CA, with a mean of 14 years, 8 months (14:8) and a range from 12:8 to 17:7.

As can be gleaned from Table 1, despite their closeness in CA, there is a large disparity in MA among the participants. Consequently, averaging over the participants to select a control group appeared problematic. We therefore decided to have two groups of controls each with 10 TD children (and an equal number of boys and

TABLE 1
Chronological Age, IQ, and Mental Age as Measured by the WISC–R for Participants with Williams Syndrome

Participant	*CA*	*IQ*	*MA*	*VIQ*	*VA*	*PIQ*	*PA*
1	12:8	76	9:6	79	10:0	77	9:9
2	14:6	92	13:4	96	14:0	88	12:9
3	13:5	52	7:0	52	7:0	61	8:2
4	12:11	45	5:8	47	6:0	55	7:1
5	13:3	40	5:0	45	5:11	45	5:11
6	17:7	43	7:6	47	8:3	49	8:7
7	14:11	69	10:3	74	11:0	68	10:1
8	15:8	46	7:3	51	8:0	50	7:9
9	17:2	53	9:1	58	10:0	56	9:7
10	17:1	50	8:6	56	9:6	52	8:9

Note. CA = chronological age; MA = mental age; WISC–R = Wechsler Intelligence Scale for Children–Revised; VIQ = Verbal IQ; VA = verbal age; PIQ = Performance IQ; PA = performance age.

girls), whose CA was at or close to the ends of the distribution of MA of the individuals with WS. The younger group (henceforth, Group I) was the same CA as the control group in Karmiloff-Smith et al.'s (1997) study. The mean CA of Group I was 5:7 (range 5:3–5:11). The mean CA of the older group (henceforth, Group II) was 11:7 (range 10:3–12:6).

Procedure

Participants with WS were tested in their homes during two or three visits. Sessions lasted over 1 hr, during which there was much play and conversation as well as testing. Each task was preceded by four familiarization items modeled after the stimuli in the task (discussed later). During the administration of the familiarization items, the investigator provided feedback as well as the correct reply, whenever necessary. The tasks were administered in the order given in the following. The investigator kept a complete protocol of the participant's behavior and of his or her comments during the sessions. This was important for coding the participants' understanding of the tasks (see later discussion). Group I was tested at school, whereas Group II was tested at home.

Noun derivations and gender inflection of animate nouns. Recall that most Hebrew words are in fact derived. Thus, if one is given a word from which the root can be extracted, that root may be cast into existing word patterns and new lexical items will be created. Hebrew nouns are marked for gender and number.

Nonce words were introduced through presentation of drawings or unfamiliar objects. The child was asked to repeat the nonce word before any question was asked. The participant was expected to use the nonce form in a noun pattern that has a clear semantics as well as give its form in the feminine. Half the novel words that the participant was expected to coin had existing roots, whereas the other half were novel words from nonexisting roots.

For example, the participant was shown a picture of a man who is ironing and was asked what he or she would call a man whose occupation is to iron clothes. The participant was then asked what he or she would call a woman whose occupation is to iron clothes. In replying to this question the participant needed to cast the root *G-H-Z* (the root for the verb *le-GaHeZ*, "to iron") in the nominal pattern for agent and coin the novel word for "a man who irons," **GHaZan* or **GHaZ*. This novel noun could also be put in a feminine form to refer to "a woman who irons," **GHaZanit* or **GHaZana*. Four questions with existing roots were presented. Each drawing included one male character. The participant had to coin a novel agent noun to refer to the male character in the picture as well as provide the novel form used to refer to a female individual.

The following procedure was used to introduce nonce nouns with novel roots: The experimenter produced a movement with his hand. The child was told that producing this movement is called **leCaKeR* (this is a morphologically well-formed infinitive of a nonexistent root, **C-K-R*). The child was asked what he or she would call a man who repeatedly did such movements. A correct (nonce) agent form in the masculine is **CiKuRan* or **CiKuR*. A correct (nonce) agent in the feminine is **CiKuRanit* or **CiKuRana*. Four such questions with novel roots were asked and the participant was required to produce a masculine as well as a feminine noun.

In sum, the test of noun derivation required that the participant coin agent nouns out of existing or nonce roots that the participant had to extract from the verb produced by the experimenter. Whereas root extraction is a formal operation, coining agent nouns requires familiarity with the appropriate word patterns that designate agents. Providing the feminine form of these newly coined nouns requires at least some conceptual understanding of the referential implications of gender-marked forms.

Production of verb forms. The procedure used to elicit verb forms was similar to the one described for nouns. The focus, however, was exclusively on the formal well-formedness of the verbs produced. The experimenter presented a picture in which a familiar action was shown. The participant was asked to describe the action. The participant was then shown another picture with a different action that required the use of the same root in a causative pattern. In this case, too, the participant was expected to reply with an existing Hebrew verb.

For example, the participant was shown a picture of a baby eating and was expected to use the verb *OXeL*, "eat," to describe the picture. The participant was then shown a picture of the father feeding the baby and was expected to say *mAXiL*, "feeding." The form *mAXiL* is the causative form of that same root, *O-X-L*. Four questions with familiar verbs were asked. Questions were in present tense, masculine, singular.

A similar procedure was used with novel roots. The participant was shown a picture in which there is an unfamiliar action. He or she was given a novel verb in a basic form and was told that this describes the novel action. The participant was then shown a different picture that could be appropriately described through the use of the same novel root, cast in a causative pattern. Four questions with novel verbs were asked. In this case, too, verbs were presented in the present tense, masculine, singular.

Note that although the questions were directed toward production of causative forms, replies were coded as correct whenever the child produced a morphologically correct verb, disregarding the specific pattern. Thus, if the child gave a form that was not causative yet was a morphologically well-formed verb, the response was scored as correct. The focus of this task was therefore on formal well-formedness rather than on the causative verb form.

Gender agreement. This test was a replication of Karmiloff-Smith et al.'s (1997) study of gender agreement in French. Whereas the French study focused on article–noun agreement, our procedure focused on agreement between nouns and adjectives. This change was necessary because Hebrew does not have agreeing articles. Our study used the same drawings that were used in the French study.[1]

Recall that agreement is a syntactic phenomenon, which is reflected in the form of the *agreeing* words, that is, articles in French and adjective endings in Hebrew. Thus, in Hebrew one knows what the gender of the noun is by observing the form of the adjective, without necessarily relying on the noun ending. This is crucial because the latter is not a fool-proof cue to the noun gender.

The procedure was the following: The participant was shown a colored drawing that had two or more identical unfamiliar objects. The experimenter said:

13. *ele* + **xashur-**im*** + *cehub-**im***
 those + *nonce noun (pl.) + yellow (pl. masc.):
 those are yellow (pl.) *nonce (pl.)

The participant was asked to repeat what the experimenter said. As can be gleaned from the example, the noun and the color adjective share the same plural ending, ***-im***. This therefore is a concordant noun–adjective combination (Karmiloff-Smith et al., 1997).

The experimenter then showed the participant another card, which had a single object that was identical to the objects shown on the previous card except for its color. The participant was asked to close his or her eyes while the experimenter hid a small ring under one of the cards. Although the participant could not see

[1]We thank Annette Karmiloff-Smith for the use of her stimuli.

where the ring was, given the bulge under the drawing of the single object, it was rather obvious where the ring had been placed. The participant then opened his or her eyes and was asked to tell the experimenter where he or she thought the ring was. In the case of statement 13, the gender of the singular nonce noun had to be masculine because the agreeing adjective had a masculine ending. The correct answer was therefore:

14. *mitaxat* + *la-xishur* + *ha-adom*:
    under definite-*nonce (masc. sing.) definite-red (masc. sing.)

Note that when the combination is concordant, that is, the plural form of the noun and the plural form of the adjective share the same ending, the form of the adjective singular can be determined on the basis of phonological cues. Such cues, however, will not resolve the problem presented by discordant combinations. The following example presents such a case. Crucially, in discordant combinations it is the ending of *the plural adjective* that informs the child what the gender of the noun is and hence what the form of the adjective singular should be. For the example:

15. *ele* + **mikdon-**_**im**_ + *vrud-**ot***
    those + *nonce noun (pl.) + pink (pl. fem.):
    those [are] pink *nonce (pl.)

the expected response is:

16. *mitaxat* + *la-mikdon-**a*** + *ha-yeruk-**a***
    under definite-*nonce (fem.) definite-green (fem. sing.):
    under the green *nonce

Thus, although the task has concordant as well as discordant noun + adjective combinations, the focus is on discordant combinations because those are the cases in which knowledge of the agreement rule is required and phonological matching of endings will not suffice. Altogether there were eight questions with discordant combinations, four in which the adjective was in the masculine plural and four in which the adjective was in the feminine plural.

RESULTS

Understanding Task Requirements

Based on participants' performance on the familiarization items preceding each task, it was clear that none of the participants had to be excluded from the study on the basis of lack of understanding of the tasks. However, some participants failed to understand specific questions. It was therefore felt that prior to any analysis, the proportion of cases of lack of understanding among the groups had to be compared to see whether, as a group, the participants with WS and the controls had similar proportions of such instances. Unless this is the case, differences among the groups will be difficult to interpret.

Instances of lack of understanding included cases in which the participant did not know that he or she had to refer to the size or the color of the drawing (as in the gender agreement task), or when the participant asked the investigator to repeat the question time and again. Refusal to answer was not considered an instance of lack of understanding. In such cases testing was discontinued and tried again on another day. Because there were no instances of lack of understanding of the tasks in the Group II controls, coding for participants' understanding of the task demands was carried out for the participants with WS and for Group I controls. Two investigators who did not participate in the collection of the data coded the files. Between-coder agreement was .92. Cases for which agreement could not be reached were excluded from the analysis.

Figure 1 gives box plots for percentages of instances of lack of understanding of task requirements for the WS group and Group I. The mean percentage of lack of understanding task requirements was 13.4% for the WS group and 6.43% for Group I. The difference between the two groups with respect to understanding of the tasks was not significant (median test; $Z = 0$).

For both Group I and the WS group, difficulty understanding task requirements was weakly and nonsigificantly negatively correlated with success on the tests

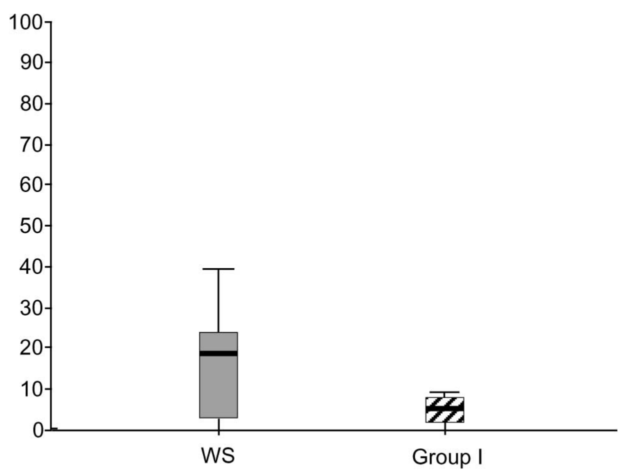

FIGURE 1 Percentage of instances of failure to understand task requirements.

(WS group: Spearman $r = -.33$; Group I: Spearman $r = -.16$). Note that the variability among individual participants in both groups was great, with some of the participants having no difficulty in understanding task requirements and others having serious difficulties. Consequently, discriminant analysis did not predict group membership.

Knowledge of Morphology

Recall that the morphological systems of interest were either meaning-related, such as noun inflections (plurality and linguistic gender on animate nouns) and noun derivations, as well as systems that are strictly formal, such as verb form, root extraction, and gender agreement on inanimate nouns.

Figure 2 presents box plots for noun derivations and for gender marking on animate nouns. Both tasks required morphological manipulations that introduced meaning modulations. Participants with WS were not significantly different from Group I, but significantly worse than Group II on gender marking on animate nouns (median test for gender on animate nouns: WS and Group II, $z = 1.96$; $p = .05$; WS and Group I, $z = 1.84$; $p < .07$). Participants with WS were significantly worse than Group II on noun derivations, but did not differ significantly from Group I on this same task (median test for noun derivations: WS and group I, $z = 1.84$; $p < .07$; WS and group II, $z = 2$; $p < .03$).

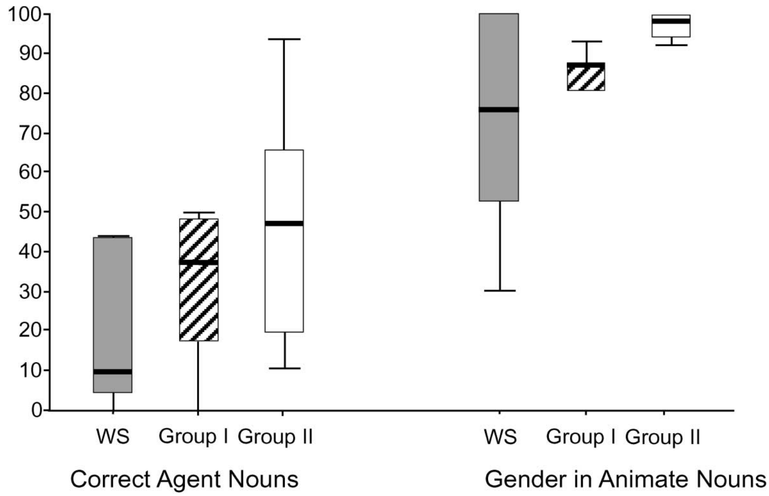

FIGURE 2 Percentage correct for coining agent nouns and gender marking on animate nouns.

Figure 3 presents box plots for two morphological systems that can be considered unrelated to meaning: root extraction and verb forms. Recall that given the systematic morphophonological structure of Hebrew words, sensitivity to roots could be evident even in cases in which the participant failed to give a correct response to the specific question asked. For example, in responding to a question concerning verb derivation the participant could use the root that he or she correctly extracted from the verb form given in the question, yet the form of the pattern might be erroneous. This would count as correct with respect to root extraction despite the fact that it would result in an incorrect verb form. Altogether, 17 of the questions asked in the different tasks required uncovering the root structure of the stimuli. For verb forms, the percentages reported in Figure 3 are for morphophonological well-formedness disregarding the semantics of the verb form.

No statistically significant difference was found between the groups with respect to ability to extract roots (WS group and Group I: $z = 0$; WS group and Group II, $z = .68$). There were no significant differences between the WS group and Group I in verb derivations ($z = 0.92$). The difference between the WS group and Group II, however, was statistically significant ($z = 3.00$, $p < .003$).

Figure 4 presents box plots related to participants' performance on the discordant combinations of noun + adjective in the gender agreement task. Recall that this task was a replication of that of Karmiloff-Smith et al. (1997). Knowledge of agreement was necessary to handle discordant combinations of nonce

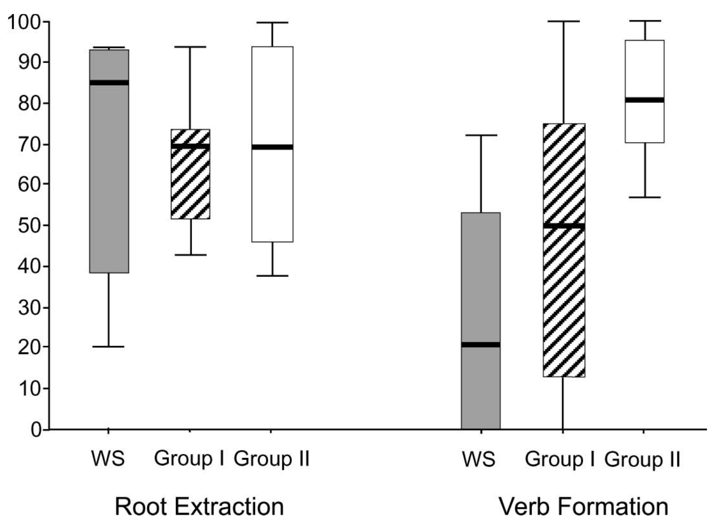

FIGURE 3 Percentage correct for root extraction and verb formation.

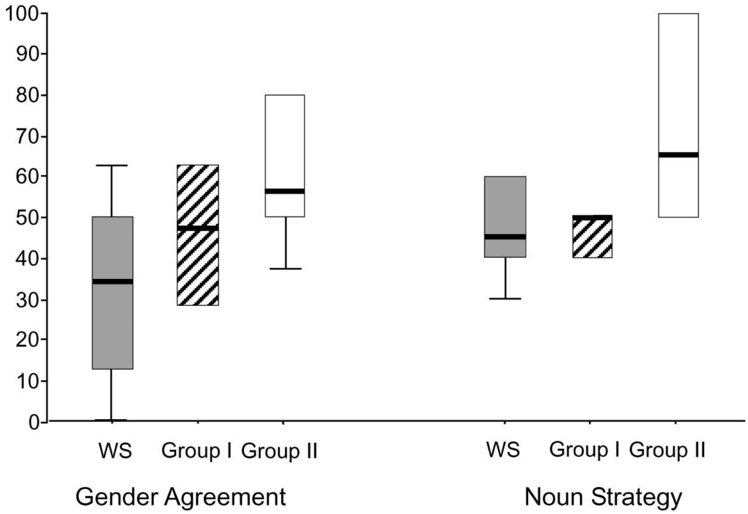

FIGURE 4 Percentage correct for gender agreement for discordant noun–adjective combinations (left) and percentage of responses that conform to application of a "noun strategy" (right).

nouns + adjectives. Differences in performance on the gender agreement task were statistically significant between the WS group and Group II (Mann–Whitney U, $Z = 2.07$; $p = .038$), but not between the WS group and Group I ($Z = 0.557$). Surprisingly, however, performance with respect to discordant combinations was poor in all the groups. Thus, contrary to our expectations, and unlike the participants in the Karmiloff-Smith et al. (1997) study, neither TD children nor participants with WS could handle the task.

In view of the poor performance on this task, we considered the possibility that the participants used a "noun strategy," namely, that replies were based on the plural ending of the noun with complete disregard of the form of the agreeing adjective. Note that such a strategy would lead to erroneous replies in the case of discordant combinations, as explained earlier. A speaker who follows such a strategy in fact ignores agreement.

The right side of Figure 4 presents box plots for the percentage of responses that conform to a noun strategy. Importantly, the performance of all three groups remains low even under the assumption of a noun strategy. Statistical comparisons between the groups were not significant. It remained to be seen whether the participants were using any strategy at all when performing this task. Figures 5 through 7 give the distribution of replies for individual participants in the different groups. Recall that there were equal numbers of questions in the masculine and in the feminine. Consideration of these figures suggests that most participants settled on a default reply, which is either masculine or feminine, ignoring agreement as well as

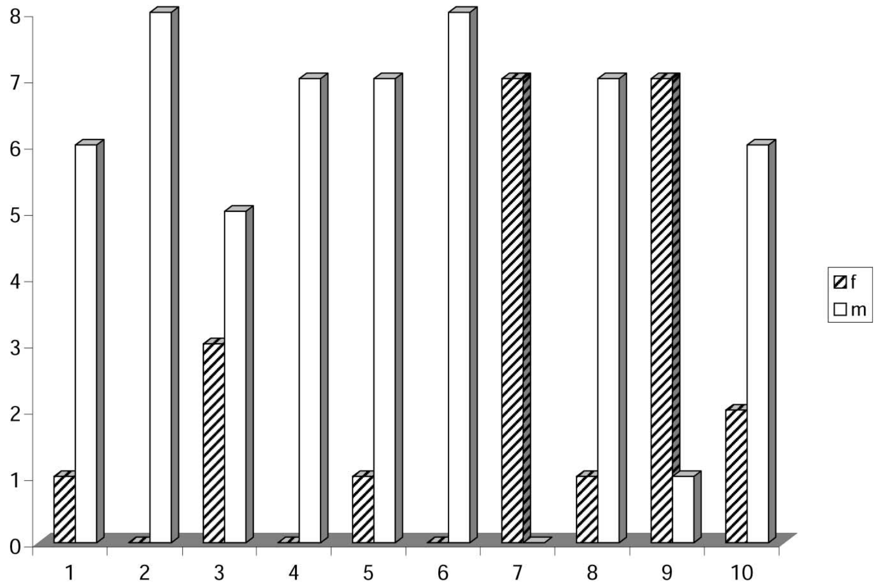

FIGURE 5 Distribution of replies to discordant noun + adjective in individual children of Group I controls.

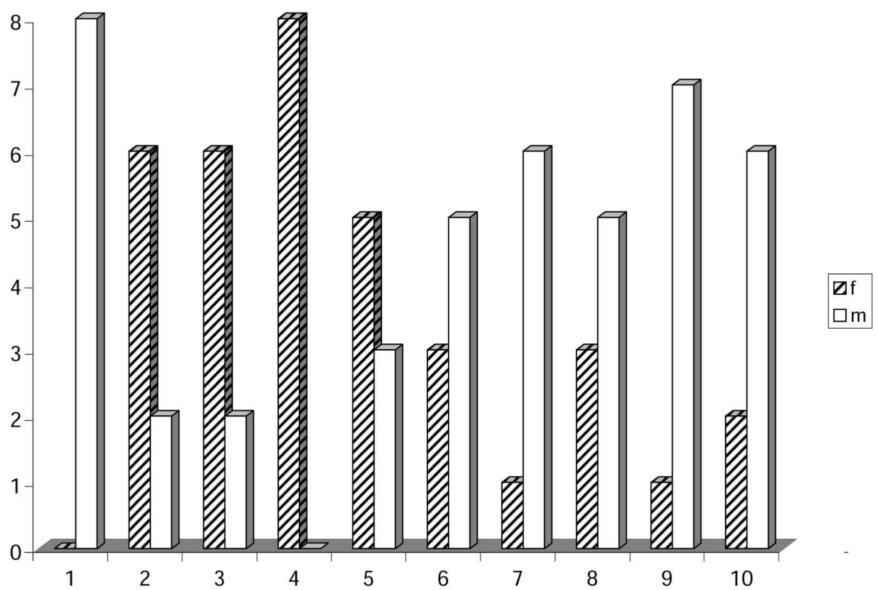

FIGURE 6 Distribution of replies to discordant noun + adjective in individual children of Group II controls.

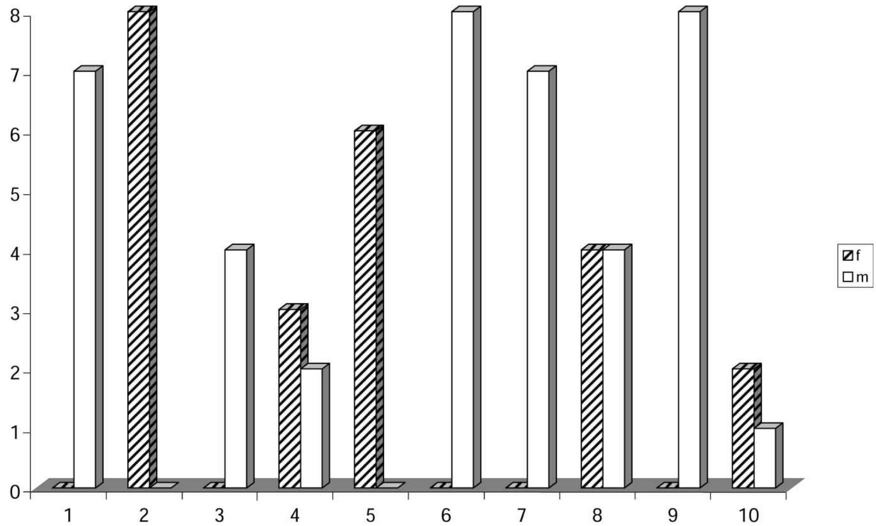

FIGURE 7 Distribution of replies to discordant noun + adjective in individual participants with Williams Syndrome.

noun ending. This is the case for the participants with WS as well as for the control groups.

Profile Analysis

Profile analysis was done through the use of partial order scalogram analysis by base coordinates (POSAC; Shye, 1985; Shye, Elizur, & Hoffman, 1994). POSAC is a technique for measuring individuals with respect to multivariate attributes. The information that can be drawn from plots produced through POSAC concerns the comparability among individual profiles that make up the groups. Rather than separating variables, POSAC considers the individual's whole linguistic profile, placing each profile in a space relative to other profiles in the sample. We may then ask the following questions: Do participants with WS resemble the controls and hence their profiles cluster such that a separation in the space is not evident? Alternatively, do the groups differ in such a way that each group occupies its own space on the POSAC plot?

POSAC (Shye, 1985; Shye et al., 1994) works in the following way: When a sample of participants is observed on certain variables (or test items) a data matrix can be produced in which each column represents a variable and each row represents a participant. The program works on a minimum of four variables with four data points but can take into consideration more variables. The data points in each row constitute the participant's profile. If the items all have a common range (i.e., they are ordered with respect to the measured attribute) order relations can be defined among profiles. Profiles are mapped onto a two-dimensional Cartesian coordinate plane preserving order relations.

Once the two-dimensional map has been plotted, the goal is to find an interpretation for the scales such that the original meaning of the common range is retained. The interpretation of these scales can be helped by observing the role of specific variables in the organization of the plotted space. Note that the axes represent general aspects of the content world rather than any individual variable. By saying that the meaning of the two coordinate scales is determined by certain variables we are not saying that the axes can be thus labeled, because the analysis is done post hoc and is based on the distribution of the profiles in the multidimensional space. The researcher may further look for a single variable that is the best predictor of the partial order among the profiles. Such a variable may or may not exist.

POSAC has the following advantages over other nonparametric analyses: All variables are simultaneously considered. Variables are not represented by other, more central variables and there are no weights given. Each variable is equally important in the analysis. Combination of variables, whether linear or nonlinear, is not attempted. POSAC is the only technique in which all of these properties coexist.

POSAC may be used for a discriminant analysis as well. That is, one can observe the extent to which a certain variable divides the space into meaningful sections. While exploring the possibility of a separation line along the POSAC space, two considerations have to be respected: (a) The line should be parsimonious, that is, as straight as possible with a minimal number of curves, and (b) the number of deviant profiles should be as small as possible.[2]

In sum, the variable of interest in this study was the group to which a participant (i.e., a profile) belongs. Do the profiles of participants with WS cluster in certain areas of the plotted space or are they indistinguishable from the profiles of either Group I or Group II of the controls? Can we predict the group from which a given profile has been drawn on the basis of its position within the POSAC space?

Figure 8 plots the POSAC profiles for the participants with WS and the controls. Each profile included four variables: root extraction and verb form, which are strictly formal systems, and noun derivations and gender on animate nouns, which are morphological systems that correlate with meaning.

[2]The procedure used to create POSAC plots maps the profiles into two-dimensional Cartesian coordinate space, so any separation procedure among profiles (i.e., profiles that belong to different groups) must take into account the coordinates on both axes. Also, theoretically the POSAC partition lines must run along the coordinate grid and must be a monotone nonincreasing curve that is looked upon as describing a function of one of the axes on the other (Shye, 1985).

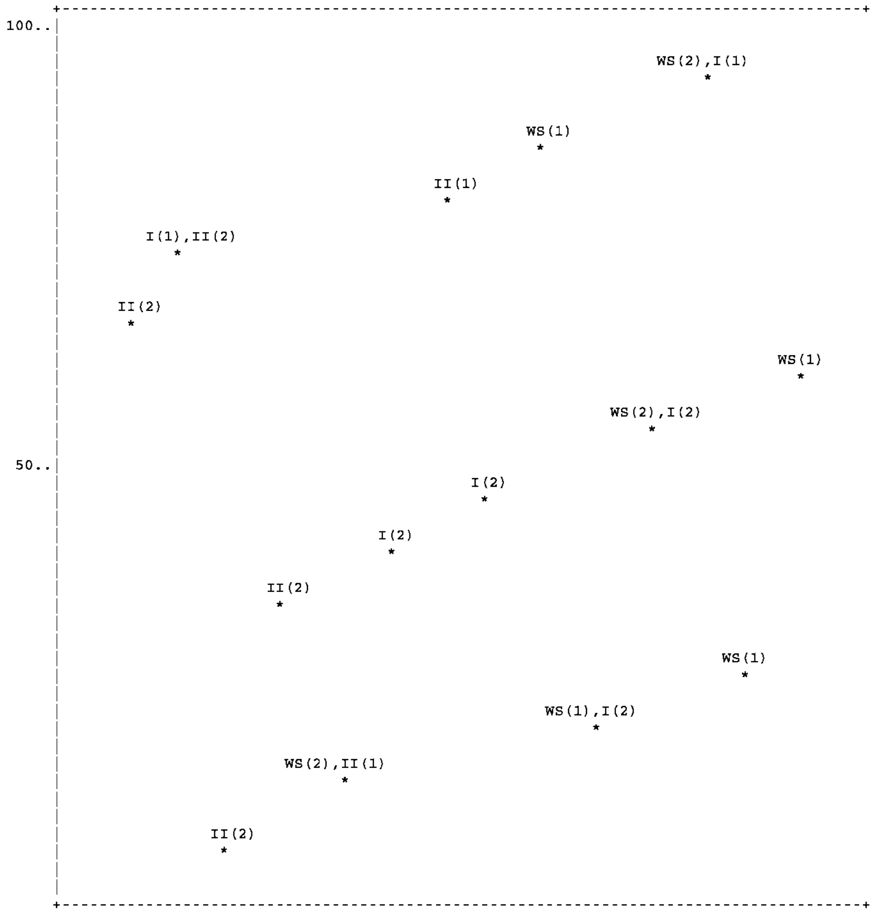

FIGURE 8 Linguistic profiles (POSAC space) of participants with WS and Groups I and II of controls.

The two-dimensional mapping in space was perfect. Although the axes are not determined by any single variable, the distribution of the profiles along the two coordinate scales in Figure 8 is correlated with percentage of correct use of roots and verb forms. No single variable that was the best predictor of the order among the profiles was found.[3]

As shown in Figure 8, the individuals with WS cannot be separated on the POSAC plot from Group I of the controls. However, none of the WS participants

[3]Recall that by saying that the meaning of the two coordinate scales is determined by certain variables we are not saying that the axes can be thus labeled, because this is a post hoc analysis.

appears to the left of the orthogonal line, that is, none of them is close in space to the Group II of the controls. Thus, when participants' fuller profiles are taken into consideration, the participants with WS are indistinguishable from the younger control group but quite separate from the older control group.

SUMMARY AND DISCUSSION

This article focuses on knowledge of Hebrew morphology in adolescents with WS and the current controversy concerning the nature of the grammatical system underlying the excellent conversational skills attributed to individuals with WS. In view of the great variability in MA seen in the WS group, we decided not to average over participants and instead chose two control groups that were at the lower and the upper ends of the distribution of MA seen in the individuals with WS.

Although no participant had to be excluded from the study due to difficulty in understanding task requirements, there were sporadic cases of lack of understanding of specific questions in both the participants with WS and the younger controls. However, level of understanding of task requirements did not differ significantly between these two groups. There were no instances of lack of understanding of task requirements in the older controls. Thus, on the face of it, difficulties in understanding task requirements may account, at least in part, for the differences in the linguistic performance among participants with WS and the older controls. A consideration of the findings to be summarized in what follows—the fact that the results are not unidirectional as they would be if this were the correct explanation—suggests that the differences among the groups reflect differences in the participants' underlying linguistic knowledge rather than problems having to do with understanding the tasks.

We studied both strictly formal morphosyntactic systems—gender agreement within noun phrases, verb forms, and root extraction—as well as morphological paradigms that serve to introduce meaning modulations—gender marking of animate nouns and derivation of agent nouns. It is the former systems that offer the strongest test for the hypothesis originally raised by Bellugi and colleagues and recently supported in the work of Clahsen and colleagues, arguing for a relative preservation of grammar in WS. Evidence against this hypothesis was brought forth by Karmiloff-Smith et al. (1997) and by Mervis et al. (1999) as well as others.

There were no significant differences among the groups in this study in ability to extract roots. Previous work on Hebrew has shown that this is a key grammatical feature of the Hebrew lexicon, to which TD children are sensitive rather early and continue to be so throughout their mature years (Levy, 1988a). Our results show that this is an aspect of the language to which participants with WS are also very sensitive. Whereas root extraction is an early acquisition with TD children, it is important to note that one may envisage alternative ways of learning the language that will not implicate high sensitivity to roots. In other words, good spontaneous Hebrew might have been present without sensitivity to the compositional structure of Hebrew words and to the grammatical status of consonantal roots. For example, a full lexicon could have been learned, aided by the participants' good auditory phonological memory (Karmiloff-Smith et al., 1997). Apparently, this is not the road taken.

Another aspect that concerns basic typological features of Hebrew is verb forms. We refer to the morphophonological alterations rather than to the semantic modulations that may be introduced through changes in verb patterns. Participants with WS performed as well as the younger controls, yet significantly less well than the older control group. Although we completely disregarded erroneous aspects of verb meaning in the coding of replies, we cannot rule out the possibility that because changes in verb forms affect meaning, this might have limited the children's success on this task. The results with respect to other morphological manipulations that involve a change in meaning, summarized in what follows, suggest that this could have been the explanation.

Contrary to our expectations, all three groups performed poorly on the gender agreement test. This was surprising, given the early age at which Hebrew-speaking children as well as children learning other languages with rich morphologies acquire linguistic gender and agreement (Berman, 1985; Levy, 1983, 1988b). A consideration of performance of individuals in the groups suggests that in all three groups participants in fact did not encode the gender information that was given in the stimuli. Agreement did not seem to be a rule with which the children worked when they performed this task. We conclude that the gender agreement task failed to test knowledge of this system in either the participants with WS or in the controls.

The interest in reporting those "nonresults" lies in the fact that despite the analogical nature of our tasks, including the fact that we used the identical stimuli and the same-age TD participants, we did not succeed in replicating Karmiloff-Smith et al.'s (1997) findings on gender agreement in French. Recently we failed to replicate the results from French in three additional groups of 7-year-old TD Hebrew speakers as well as in 6-year-old TD Spanish children (Levy & Tolchinsky, in preparation).[4] Given that Spanish is very similar to French, in that both languages have agreeing articles and consequently the procedure was identical in both studies, this failure to replicate is troublesome. More work is needed to account for the discrepancies.

A comparison of the performance of the participants with WS and the controls on the morphological paradigms that introduce meaning modulations indicated that the older control group performed significantly better than the WS group on

[4]In a series of experiments we tried to impute a meaning to the nonce words in the hope that children would apply agreement rules to them. Preliminary results do not show any improvement on the task, that is, 7-year-old Hebrew speakers still fail to apply agreement to mismatched pairs of nonce noun + adjective combinations.

both gender marking of animate nouns and coinage of agent nouns. The difference in performance between the WS group and the younger control group was not significant. Note that sensitivity to the typological features of Hebrew along with difficulties in morphology that involve meaning is not characteristic exclusively of individuals with WS. A similar language profile can be seen at an earlier developmental phase in individuals with other neurological syndromes who have similar levels of intellectual handicaps (Levy et al., 2000).

A comparison among the groups based on children's fuller morphological profile, produced in the form of a POSAC plot, suggests the direction that these results are taking. The mapping of individual profiles in a two-dimensional space did not show a separation between profiles of the participants with WS and those of the younger control group. A separation in space did exist, however, between the WS group and the older control group. Thus, when a more comprehensive morphological profile of a child is considered, involving morphological manipulations that are exclusively formal as well as those that involve aspects of meaning, the profiles of participants with WS are more like those of TD children who are at the lower end of the MA range for the participants with WS than those of TD children who are at the upper end of the MA range for the participants with WS.

In sum, with respect to the debate between Karmiloff- Smith et al. (1997; Karmiloff-Smith et al., 1998) and Clahsen and Almazan (1998) and Clahsen and Temple (2003), the findings relating to knowledge of word structure in Hebrew-speaking adolescents with WS are inconclusive. Although knowledge of the root structure of the Hebrew lexicon is at MA level, other features of morphology seem less preserved. Given how central a typological feature this is for Semitic languages (Hebrew as well as Arabic), the fact that children with WS are sensitive to roots is perhaps not so surprising.

Still, information is needed relating to gender agreement before one can argue that the data from Hebrew support the idea of preservation of grammar in WS. Gender agreement is particularly important in this regard because it is a formal syntactic rule that has morphological consequences but no meaning attached to it. Furthermore, as shown in the discussion of the task analysis, in the absence of an agreement rule, it is possible to predict a pattern of errors that may turn out to be very revealing, for example, if there was evidence for the adoption of a noun strategy.

With respect to the other systems studied, the WS group performed mostly at the lower end of their MA range. We conclude therefore that there is little evidence from Hebrew to support a selective preservation of grammatical competence in individuals with WS.

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