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Article

Verb Comprehension and Use in Children and Adults With Down Syndrome

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Purpose: Expressive syntax is a particular area of difficulty for individuals with Down syndrome (DS). In order to better understand the basis for sentence formulation deficits often observed in children and adults with DS, the authors explored the use and comprehension of verbs differing in argument structure.
Method: The authors examined verb and argument structure retrieval in 18 individuals, 9 with DS, age 11;11 (years;months) to 32;10 and 9 receptive vocabulary age-matched typically developing (TD) children, age 3;2 to 13;6. Participants completed verb and noun comprehension tasks, a working memory assessment, verb and noun naming tasks, grammaticality judgments, and narrative tasks.
Results: Neither single verb comprehension nor single verb naming differentiated the DS and TD groups. Individuals with DS performed significantly worse than individuals who are TD when asked to judge sentence grammaticality. Individuals with DS omitted verbs in elicited narratives significantly more often than individuals who are TD, specifically when productions of 2-place and 3-place verbs were attempted. Individuals with DS also omitted other necessary elements of argument structure, such as subjects, in sentences containing 2-place and 3-place verbs significantly more often than individuals who are TD. Performance was not related to working memory skills.
Conclusions: Results indicate that individuals with DS do display a specific expressive deficit in verb and argument structure retrieval (but not comprehension) that varies as a function of verb type (1 place, 2 place, and 3 place).

Key Words: Down syndrome, language, verbs, comprehension, production

Down syndrome (DS), or *trisomy 21,* is a condition caused by an extra copy of chromosome 21 present in the cell nuclei, that leads to numerous developmental abnormalities (Jarvik, Falek, & Pierson, 1964), including cognitive impairment. In particular, individuals with DS show deficits in verbal short-term or working memory (Bower & Hayes, 1994; Chapman, 2006; Laws, 2004), even when compared with other individuals who are learning impaired. In contrast, they perform as well or better than individuals who are learning disabled but do not have DS, on tasks that rely on storing, retaining, and retrieving *visual* information (Bower & Hayes, 1994; Chapman, 2006; Rowe, Lavender, & Turk, 2006), suggesting that the deficits are language specific.

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Individuals with DS have difficulty in a variety of other areas of language as well (Byrne, Buckley, MacDonald, & Bird, 1995; Caselli, Monaco, Trasciani, & Vicari, 2008; Chapman & Hesketh, 2000; Chapman, Schwartz, Kay-Raining Bird, 1998; Eadie, Fey, Douglas, & Parsons, 2002; Fabretti, Pizzuto, Vicari, & Volterra, 1997; see Chapman & Hesketh, 2000, 2001, for reviews). Although individuals with DS perform similarly to children who are typically developing (TD) with comparable cognitive abilities (mental ages) on comprehension in a variety of linguistic tasks (Chapman et al., 1998; Ypsilanti, Grouios, Alevriadou, & Tsapkini, 2005), they perform less well when asked to define words, suggesting that expressing knowledge about stored vocabulary is an area of weakness. However, their greatest deficits appear to be in the domain of syntax.

Individuals with DS, compared with individuals who are matched for mental age, exhibit impaired expressive syntax in narration, conversation, and in repetition tasks (Chapman et al., 1998; Seung & Chapman, 2004), often omitting sentence elements or making morphological errors (such as tense and plural formation errors; Caselli et al., 2008; Chapman & Hesketh, 2000; Eadie et al., 2002; Vicari, Caselli, & Tonucci, 2000; Ypsilanti et al., 2005).

These deficits appear to exceed those seen in vocabulary comprehension in the same individuals (Chapman, Schwartz, & Kay-Raining Bird, 1991). Although syntactic skills continue to develop in adolescents with DS, mastery and use of syntax appears more impaired than lexical skills (Thordardottir, Chapman, & Wagner, 2002). These profiles may be the result both of a lack of knowledge and a lack of sufficient cognitive resources (memory, attention) during performance tasks. Mean length of utterance (MLU) is reduced in individuals with DS (Chapman et al., 1998; Chapman & Hesketh, 2000; Vicari et al., 2000), and their language has been described as telegraphic, with many words missing (Vicari et al., 2000). Verbs seem to be particularly omitted (Caselli et al., 2008; Hesketh & Chapman, 1998). For example, when asked what one does during free time, an individual with DS might respond "cookies," whereas an individual who is TD might say, "(I) bake cookies."

Main verbs and auxiliary verbs are likely to be omitted. However, individuals with DS do not produce significantly fewer different verbs, and in fact, they produce a significantly greater variety of main verbs than do individuals who are TD on some tasks (Hesketh & Chapman, 1998; Vicari et al., 2000). Thus, it appears that individuals with DS possess an adequate number of verb entries in the mental lexicon (as supported by their generally accurate comprehension skills), but these entries are not accessed well during production tasks.

Verb entries contain syntactic as well as semantic information. In English, this syntactic information includes argument structure (Kim & Thompson, 2000). Verb argument structure specifies the number of nouns that either may or must accompany the verb in a clause. Different English verbs require different numbers of arguments. Verbs such as *laugh* require only one argument, a subject (e.g., *She laughed*); they are considered one-place verbs, or intransitive constructions. In fact, insertion of more than one argument results in an ungrammatical sentence (e.g., *She laughed the joke*.*) In contrast, a verb such as *give* requires three arguments: a subject, direct object, and indirect object (e.g., *She gave the letter to the boy.*) Absence of any one of these three leads to an incomplete sentence (thus, *She gave the letter** and *She gave to the boy** are both ungrammatical). It is, therefore, considered a three-place verb. *Lift* is an example of a two-place verb (e.g., *She lifted the bag.*). Of course, some verbs also permit additional, optional arguments (e.g., *She lifted the bag on the street.*).

Inability to access a verb's full entry in the lexicon could result in omission of either the verb or other necessary syntactic elements in an utterance. This could be one explanation of the reduced MLU characteristic of DS language profiles. Alternatively, the representations of verb entries may themselves be incomplete or poorly organized, in which case the storage of the verb entry may be the point of breakdown, rather than the access of the entry. Individuals with DS not only omit verbs but also omit elements of their argument structure (Grela, 2003; Layton & Sharifi, 1978). In addition, individuals with DS omit more subject arguments as well as other noun phrase constituents, such as articles and prepositions, than do TD children matched for MLU (Caselli et al., 2008; Chapman & Hesketh, 2001; Grela, 2003; Layton & Sharifi, 1978).

A similar pattern has been observed in agrammatic aphasia. Kim and Thompson (2000, 2004) found that participants with agrammatic aphasia exhibited particular difficulty with verb production. Despite showing high and comparable accuracy in the *comprehension* of nouns and verbs, the patients performed significantly worse when naming verbs compared with nouns. Furthermore, three-place verbs were incorrectly named significantly more often than were two-place verbs, which were incorrectly named significantly more often than one-place verbs. In a similar way, in a narrative task, one-place verbs were produced with correct argument structure significantly more often than the other two types. These findings suggest that verb access in agrammatic aphasia is influenced by the number of arguments associated with the verb. This is true regardless of the optionality of the arguments. That is, one-place verbs were significantly easier to categorize, retrieve, and produce with correct argument structure than obligatory and optional two-place and three-place verbs.

The similarity of verbal profiles in DS and agrammatic aphasia suggests the possibility that the language production of individuals with DS may also be affected by argument structure. Grela (2003) analyzed transcripts taken from a database of child–caregiver interactions by coding main verbs for argument structure and tallying absence of obligatory arguments and addition of illegal arguments. No significant differences were found between children with DS and TD children matched for mean length of utterance as a function of verb category or argument position for one- and two-place verbs. Children did not produce any three-place verbs. However, spontaneous language samples may not provide sufficient analytical power because individuals with DS may not spontaneously produce an adequate number of each verb type to sufficiently analyze verb and argument structure production as a function of verb type. To evaluate how argument structure affects verb comprehension and expression in individuals with DS, equal opportunities to access and produce each verb type and their arguments should be provided, suggesting the need to examine this issue in a more structured experiment. In addition, it is important to evaluate verb comprehension and access separately, to identify where a potential deficit may lie. In this study, we asked whether individuals with DS differ in their verb processing and production profiles from those seen in individuals who were receptive vocabulary age matched and TD, and whether these profiles differ as a function of verb type (i.e., one-, two-, and three-place verbs). We also explored whether any differences in verb-processing abilities would be related to their known deficits in working memory when compared with peers of similar mental age (see Seung & Chapman, 2000; and Jarrold, Nadel, & Vicari, 2009, for extended discussion). For example, Mosse and Jarrold (2011) did not find impacts of working memory capacity on novel word learning in individuals with DS. We sought to assess its relationship to syntactic ability. We hypothesized that individuals with DS would demonstrate a specific deficit in argument structure that would be more evident as the number of verb arguments in a sentence increased. Finally, given the literature that specifically has revealed syntactic deficits in individuals with DS that exceed those seen in other domains, we hypothesized that these deficits would not merely reflect general deficits in working memory capacity.

Method

Participants and Matching Procedures

Nine individuals with DS and nine receptive vocabulary age-matched controls participated. Individuals with DS were recruited through local county groups and organizations for parents with children who have DS and for older individuals with DS by using flyers and electronic postings to these groups; TD children were recruited through the same organizations and through a University of Maryland database of families who are interested in participating in research. All participants were given the Peabody Picture Vocabulary Test—Fourth Edition (PPVT–4; Dunn & Dunn, 2007) by the first author, to make pairwise matches for receptive vocabulary age. Individuals who are TD were considered a match for an individual with DS if they were the same gender and had a PPVT–4 raw score within 5 points of the score of the individual with DS. A total of 19 individuals with DS initially participated in the study. Four were excluded from analysis due to substantial (> 50%) exposure to a second language from a young age; 2 participants failed a hearing screening at all frequencies, at both 20 dB and 40 dB, in both ears. One participant with DS was excluded from analysis because of a notably low raw score on the PPVT–4 (58), for which a typically developing match would have been too young to participate in this study (i.e., under 3 years old). Of the 12 remaining participants with DS, 9 were successfully matched to typically developing children for gender and PPVT–4 raw score and were included in the final analysis. The individuals with DS had a mean PPVT–4 raw score of 112.9 (range = 74–183), and the individuals who are TD had a mean PPVT–4 raw score of 114.9 (range = 73–185), $t(8) = -0.1201$, $p = .907$, *ns* (see Table 1).

Participants with DS ranged in age from 11;11 (years;months) to 32;10, with a mean age of 18.9 years. As might be expected, individuals in the control group were considerably younger, ranging in age from 3;2 to 13;6 with a mean age of 6.1 years. Detailed information about participants is recorded in Table 1.

Participants' hearing was evaluated using a pure-tone audiometric screening test at 500, 1000, and 2000 Hz at 20 dB and 40 dB to confirm adequate ability to hear all experimental instructions and stimuli. All participants passed the screening at all frequencies at 40 dB, and all but 2 individuals with DS passed the screening at all frequencies at 20 dB. One of the individuals with DS was aided in the right ear and had a threshold at 25 dB. The other individual with DS failed at 1000 and 4000 Hz in his

Table 1. Participant characteristics. Participant (matched pairs) ages (years;months), Peabody Picture Vocabulary Test—Fourth Edition (PPVT–4) raw scores, and genders (F = female, M = male). DS = Down syndrome; TD = typically developing.

	DS participants		TD participants		
Pair no.	Age (years;months)	PPVT–4 raw score	Age (years;months)	PPVT–4 raw score	Gender
1	16;0	183	13;6	185	F
2	17;0	96	5;2	101	F
3	19;4	113	6;6	114	M
4	15;1	83	4;5	88	F
5	32;10	147	7;10	152	M
6	11;11	74	3;2	73	F
7	24;0	82	3;4	84	F
8	17;4	114	5;0	109	M
9	16;8	124	5;7	128	M

left ear, but he passed at all frequencies in the right ear. Because both participants had normal hearing unilaterally, they were judged to have adequate hearing to participate in this study.

Stimuli and Procedures

Testing was completed during two sessions for all participants and took place in quiet locations in participants' homes (one individual with DS was tested in his day care placement). The first session consisted of the PPVT–4 (Dunn & Dunn, 2007), a digit-span task, a word-span task, a sentence-repetition task, a single-word-naming task, and the hearing screening. The second session consisted of a digit-span task that required nonverbal response, a word-span task with nonverbal response, a spatial-memory task, a single-word comprehension task, a grammaticality judgment task, and a narrative task. Each session lasted approximately 1 hr. Task order was fixed for all participants. Feedback on the accuracy of participants' responses was provided during the practice trials for all tasks. Each task and its corresponding stimuli are described below.

Memory Tasks

Nonverbal response tasks. Three memory tasks that require nonverbal response were administered: a digit-span task, a word-span task, and a spatial-memory task. These tasks were developed for the assessment of verbal and nonverbal short-term memory in patients who are brain damaged (De Renzi & Nichelli, 1975). For the digit-span task, participants were provided with digit strings of increasing length, presented verbally. After each string, all participants were provided with a piece of paper with the stimulus digits 1–9 arranged in a random 3 × 3 design and were asked to point to the digits in order. Similarly, during the word-span task, participants were provided with word strings of increasing length (e.g., bread–cup–ladder), presented verbally and were asked to point to the appropriate picture in a 3 × 3 array. The spatial-memory task used the same material as the digit span, but the experimenter pointed to the digits rather than presenting them verbally.

All participants were provided with two practice strings at the beginning of each task, which they were required to pass to participate further in the task, and then were presented with pairs of strings of increasing length (i.e., 2 two-item strings, 2 three-item strings, etc.). Participants were given 1 point for one correct string in a pair and an additional .5 point if the second string was also correct. Administration was discontinued when a participant failed both items in a pair. Participants were required to pass admission criteria for each nonverbal memory task to participate; all did so except for 2 individuals with DS who failed admission criteria for the digit-span task and, therefore, did not participate in that task. Administration for the nonverbal memory tasks lasted approximately 10–15 min.

Verbal response tasks. Three memory tasks that require verbal response were given: a digit-span, a word-span, and a sentence-repetition task. All three are from the Test of Auditory Processing Skills—3 (TAPS–3; Martin & Brownell, 2005) and are designed to measure auditory working memory. For the digit-span task, participants are provided verbally with digit strings of increasing length and must repeat each string immediately after presentation. The same protocol was repeated with word strings and sentences of increasing length.

All participants were provided with two practice strings at the beginning of each task. Consistent with the TAPS–3 scoring guide, participants were given 2 points for strings repeated correctly, 1 point for strings in which all digits or words were recalled but out of order, and 0 points for strings with omissions, substitutions, or insertions. For each task, admission was discontinued when participants made three consecutive 0-point responses. All participants completed all three tasks in approximately 10–15 min.

Naming and Comprehension Tasks

Stimuli. Lists of 36 verbs and 36 nouns, matched for cumulative frequency (Francis & Kučera, 1982) and number of syllables, were used for the naming and comprehension tasks; these were the same as those used by Kim and Thompson (2000, 2004) and are listed in Appendix A. A number of words can be used as both nouns and verbs; all but three words are used in their intended form at least 75% of the time (Francis & Kučera, 1982); see Appendix 1. Two verbs (*bark, cry*) and one noun (*arm*) were included, despite having greater than 25% usage in the other form class, because the meaning of the word differs across forms.

The verbs were classified as one-place, two-place, or three-place verbs, based on the number of arguments associated with that verb. Verbs were considered two-place or three-place regardless of the optionality of the arguments that may appear with those verbs, because optionality of arguments did not affect the ability of patients with agrammatic aphasia on naming and categorization patterns (Kim & Thompson, 2000).

Frequency and phonological properties of words can potentially affect the accuracy and efficiency of word retrieval. To ensure that these factors could not play a role in our results, we carefully matched our sets on the following properties: (a) Log-based frequency counts (based on both the Francis & Kučera, 1982, adult corpus and the Carroll, Davies, & Richman, 1971, child corpus);

(b) number of phonological neighbors (counting all words in a 20,000-word dictionary with at least a 6.0 on a 7-point familiarity rating scale; Nusbaum, Pisoni, & Davis, 1984) that differed from the target by a single phoneme); (c) frequency-weighted neighborhood density; and (d) the frequency with which the general sound pattern of the target word is encountered (i.e., phonotactic probability), whether measured by phonemes or biphones (see Vitevitch & Luce, 2004). There were no significant differences either between nouns and verbs or among the three verb types on any of these factors.

Hand-drawn, black-and-white line drawings served as stimuli for the tasks involving single words. All stimulus-item drawings used in the comprehension and naming tasks (including distractor pictures) had been piloted in a naming task with 10 typically functioning adults. All drawings elicited target responses in at least 90% of piloted responses.

All participants completed both the naming and comprehension tasks. The same 36 verb and 36 noun targets were used for both tasks. The naming task was administered during the first session, and the comprehension task was administered during the second session.

Single-word naming. During each trial, participants were presented with a line drawing on a Macintosh laptop, and their response was recorded by using a portable digital voice recorder. Noun and verb naming trials were administered separately. Participants were told whether the following pictures would illustrate things or actions, and they were provided with two practice items before each portion of the task. For this, as well as all subsequent tasks, participants were required to pass the practice items before moving to the main task. Five individuals with DS and 5 individuals from the control group received the noun portion of the task first, and the others received the verb portion of the task first. Participants were given 20 s to respond on each trial. Semantically appropriate responses (e.g., *cup* for *glass*) were considered accurate; for verbs, these were required to have the same argument structure as the targets (e.g., *mix* for *stir, jog* for *run*).

Single-word comprehension. During each trial of the comprehension task, participants saw four drawings representing the target word, a semantically related foil, a phonologically related foil, and an unrelated word. Examples of such sets are ***bark****, meow, bake, kneel*; ***cry****, laugh, fry, weigh*; and ***hat****, belt, bat, star*. The position of the target word was counterbalanced across trials and was the same for all participants. Trial order was randomized for each participant. Participants were instructed to point to the appropriate image; nouns and verbs were administered separately as in the naming tasks. Participants were given a two-item practice set at the beginning of both the noun and verb comprehension portions of the task. If participants provided more than one response during the comprehension task, they were cued to provide their final answer.

Grammaticality Judgment Task

All sentences used in the grammaticality judgment task were designed to evaluate the ability to detect grammatical errors in argument structure, modeled after the grammaticality task used by Kim and Thompson (2000, 2004). The task consisted of 44 sentences that contained verbs with one, two, or three obligatory arguments, all of which were used in the naming and comprehension tasks (except two additional verbs with three obligatory arguments, *lean* and *stick*; these cannot appear in the other constructions). All sentences were in the present tense, with subject–verb–object word order; half were grammatical and half ungrammatical. Of the grammatical sentences, half (11) included solely obligatory arguments for each verb type, and half included obligatory arguments plus an adjunct (optional) argument. Of the ungrammatical sentences, 12 included omission of one or two obligatory arguments and 10 included addition of an illegal argument. There was no significant difference between the grammatical and ungrammatical sentences in sentence length (no. of words; mean grammatical: 7.5; mean ungrammatical: 6.5; Mann–Whitney U converted to $Z = 1.198$, *ns*). Example stimuli appear in Appendix B. The examiner presented all sentences verbally while the sentence was viewed in print on the laptop. Participants were instructed to indicate whether "each sentence sounds (good/OK/grammatical) or (bad/silly/ungrammatical)" by pointing to either a happy face (good grammar) or a frowning face (bad grammar). They were told to respond on the basis of grammaticality, not content. Participants were provided with a four-item practice set consisting of two grammatical sentences (one with solely obligatory arguments and one with obligatory arguments plus an adjunct argument) and two ungrammatical sentences (one with omission of one obligatory argument and one with the addition of an illegal argument). Corrective feedback was given during example sentences. Target sentences were presented in random order, and participants were given 20 s to respond on each trial. All subjects completed the grammaticality judgment task.

Narrative Task

Participants were asked to narrate simple scripts (e.g., a person getting ready for work) elicited by four sequenced, hand-drawn, black-and-white pictures, after the story was modeled by the examiner. Example story prompts are provided in Appendix C. Participants were presented with the pictures, one at a time, and were asked to follow along as the examiner narrated the story. The examiner provided a sentence for each picture. Participants were then provided with the same sequence, and were asked to retell the story to the examiner. They were encouraged to produce one utterance for each picture, and all participants did so. All four pictures were present during the retell task. Participants were presented with one practice story followed by nine test stories in random order. Corrective feedback was given during the practice story. Three of the test stories highlighted one-place verbs, three highlighted two-place verbs, and three highlighted three-place verbs. In each story of four sentences, three sentences were considered target sentences that contained the highlighted verb type (one-, two-, or three-place). The mean number of words per story was 23.6 for one-place stories and 24 for two-place and three-place stories. For target sentences, the average number of words was 5.9 for one-place stories, 6.2 for two-place stories, and 6.7 for three-place stories. Narratives were recorded and transcribed to identify (a) the percentage of target utterances that included verbs, both overall and per verb type; (b) the proportions of target verbs produced overall and for each verb type; and (c) the proportions of target verbs produced with correct argument structure, both overall and for each verb type. Elements of argument structure were considered present and accurate if any word representing the element of argument structure in question was present. For example, "*Mary give cookie her*" was considered accurate because the three obligatory elements of argument structure were present (*Mary, cookie,* and *her*), even though additional words (such as the determiner "a") were absent. Optional two-place verbs were considered to have accurate use of argument structure if a subject element was present. The optional three-place verbs *bake, cut, knit, read, sew,* and *write* were considered to have accurate use of argument structure if a subject element was present; the verb *fry* was considered to have accurate use of argument structure if a subject and direct object were present. Unintelligible sentences were excluded from analysis; this included one sentence from each of 4 participants with DS (2 two-place sentences and 2 three-place sentences). A second judge, blind to participant group as well as verb-type classifications, scored the accuracy of argument structure scores in each target sentence using the written transcripts of the responses. Interrater reliability was greater than 90% for argument structure accuracy for all target sentences as well as by verb type.

Analyses

In preliminary analyses, assumptions of homogeneity of variances were not met for most comparisons. Therefore, all two-sample tests were performed by using a nonparametric test (Mann–Whitney, corrected for tied ranks and converted to yield a *z* score). Although members of the two groups were matched on PPVT, there are many other factors on which they were not paired, and, thus, we are conservatively treating them as unpaired groups. Cohen's *d*s are used as measures of effect size. Spearman rank order correlations were used for all measures of correlation and reliability. Proportioned accuracy scores converted into arcsine values were used for analyses for all tasks except for the memory tasks, for which raw scores were used, and the reaction time measures, for which time in milliseconds was used.

Results

Memory Tasks

Tasks Requiring Nonverbal Responses

Consistent with our hypothesis that participants with DS would score similarly to typical matches on nonverbal tasks, no statistically significant differences were found between the DS and TD groups for any memory tasks that require a nonverbal response: digit span (DS, M = 2.9, SD = 1.7; TD, M = 4.6, SD = 2.2; Mann–Whitney z =1.4875, *ns*); word span (DS, M = 3.1, SD = 1.3; TD, M = 3.5, SD = 2.3; Mann–Whitney z = 0.1776, *ns*); or spatial memory (DS, M = 3.9, SD = 1.3; TD, M = 4.3, SD = 2.1; Mann–Whitney z = 0.1777, *ns*).

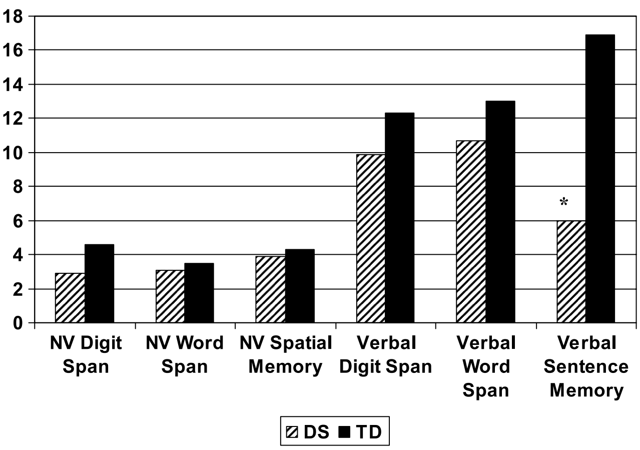
Tasks requiring verbal responses. It was predicted that the individuals with DS would perform more poorly than the TD control group on memory tasks that require a verbal response. However, analyses revealed no significant differences between groups on either the digit-span task (DS, M = 9.9, SD = 4.5; TD, M = 12.3, SD = 4.5; Mann–Whitney z = 1.2965, *ns*) or the word-span task (DS, M = 10.7, SD = 4.5; TD, M = 13, SD = 4.9; Mann–Whitney z = 0.9931, *ns*). However, a significant difference was found on the sentence memory task (DS, M = 6, SD = 4.8; TD, M = 16.9, SD = 6.6; Mann–Whitney z = 3.0147, p = .003; see Figure 1). Effect size was large (d = 2.01).

Summary, memory tasks. The DS group performed significantly worse than the TD group on the sentence memory task, while performing similarly to the TD group on all other measures of memory skills. This suggests that their memory deficits are not tied to linguistic stimuli or verbal responses, per se, but may instead be tied to language processing.

Verb Comprehension and Production

Single-word comprehension. It was hypothesized that groups would perform similarly on both the noun and verb portions of the single-word comprehension task, and this was the case for nouns (DS, M = 0.97, SD = 0.002; TD, M = 0.97, SD = 0.004; Mann–Whitney z = 0.7516, *ns*) and verbs (DS, M = 0.88, SD = 0.008; TD, M = 0.92, SD = 0.009; Mann–Whitney z = 1.2033, *ns*).

Figure 1. Performance for tasks requiring non-verbal and verbal responses. DS = Down syndrome; TD = typically developing. *p = .003.



Single-word naming. We predicted that the DS group would perform worse on the verb portion of the single word-naming task than the TD group and that the groups would perform similarly on the noun portion of the naming task. However, no significant difference was found between the DS and TD groups for either accuracy on the noun-naming task (DS, M = 0.86, SD = 0.007; TD, M = 0.85, SD = 0.105; Mann–Whitney z = 0.0890, *ns*) or the verb-naming task (DS, M = 0.51, SD = 0.237; TD, M = 0.64, SD = 0.197; Mann–Whitney z = 1.2369, *ns*). In addition, the groups were compared for proportions of target noun and verb responses (not including other semantically appropriate, accurate responses). No significant differences were found on either the noun-naming task (DS, M = 0.78, SD = 0.11; TD, M = 0.79, SD = 0.11; Mann–Whitney z = 0.2233, *ns*) or the verb-naming task (DS, M = 0.45, SD = 0.24; TD, M = 0.56, SD = 0.22, Mann–Whitney z = 0.9825, *ns*).

Narratives. It was hypothesized that the DS group would produce fewer verbs in their narratives compared with the TD group, indicating a specific deficit in verb retrieval, and this prediction was upheld. There was a significant difference between groups on the percentage of target sentences containing verbs (DS, M = 0.84, SD = 0.18; TD, M = 0.99, SD = 0.02; Mann–Whitney z = 2.1866, p = .029). Effect size was large (d = 1.28).

We also performed ancillary analyses of the narratives, to place the groups' performance into a larger perspective in regard to overall language skills. Although matched by receptive vocabulary, individuals with DS produced fewer words than individuals who are TD during this task (DS, M = 138.2, SD = 67.1; TD, M =191.4, SD = 4.2; Mann–Whitney z = –1.59, p = 11, *ns*). Their sentences were also shorter in mean length (measured in words; DS, M = 3.81, SD = 1.8; TD, M = 5.3, SD = 0.34; Mann–Whitney z = –1.59, p = .112, *ns*). Type-token ratios (TTR) were somewhat lower for participants with DS (DS, M = 0.464, SD = 0.15; TD, M = 0.539, SD = 0.003; Mann–Whitney z = 1.02, p = .31, *ns*), even though the frequent omission of sentence elements by the individuals with DS may have elevated their TTR values somewhat.

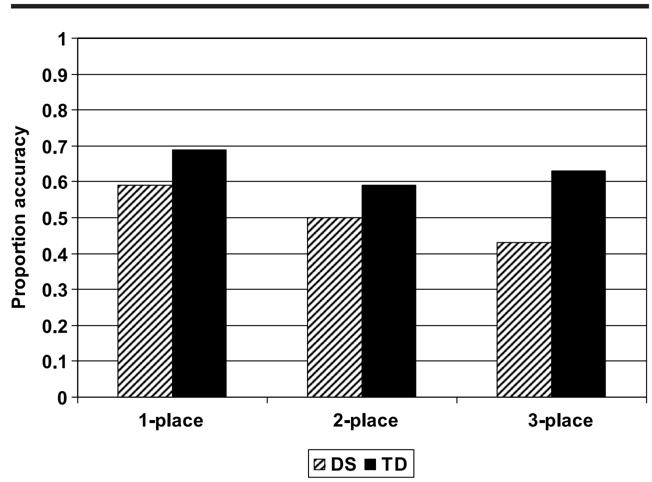
Grammaticality judgments. It was hypothesized that the DS group and the TD group would perform similarly on the grammaticality judgment task. However, analyses revealed a significant difference between the DS group and the TD group on the grammaticality judgment task (DS, M = 0.55, SD = 0.16; TD, M = 0.74, SD = 0.20; Mann–Whitney z = 2.0373, p = .042). Effect size was large (d = 1.12). The DS group performed significantly more poorly than the TD group on the grammaticality judgment task. Their mean accuracy score (.55) indicates that the DS group performed at near chance level.

Summary, verb comprehension, and production measures. In general, the DS and TD groups performed similarly on single-word tasks, but the DS group omitted verbs from target sentences in their narratives and showed poor grammaticality judgment abilities.

Verb and Argument Structure Processing and Production

Single-word verb naming. Although no significant difference was found between the DS group and the TD group on accuracy of single-word verb naming, there was a slight trend for both groups to have more difficulty retrieving verbs as the number of arguments increased (see Figure 2). The pattern was more consistent in the DS group (more difficulty with verb retrieval as the number of arguments increases) but only represents an approximate one-item difference in performance between one-place and three-place verbs. A Tukey–Kramer multiple comparison test showed that no

Figure 2. Verb naming as a function of argument structure.



significant differences were found between verb-naming accuracy for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

Narratives. The number of verb arguments could hypothetically affect both the production of the verbs themselves and the production of their arguments; we predicted that both would be the case. We found that the DS group omitted significantly more verbs than the TD group for both two-place (DS, $M = 0.85$, $SD = 0.16$; TD, $M = 1$, $SD = 0$; Mann–Whitney $z = 2.7892$, $p = .005$; large effect size, $d = 1.43$) and three-place target sentences (DS, $M = 0.80$, $SD = 0.28$; TD, $M = 1$, $SD = 0$; Mann–Whitney $z = 2.1259$, $p = .034$; large effect size, $d = 1.08$), although not for one-place sentences (DS, $M = 0.86$, $SD = 0.16$; TD, $M = 0.98$, $SD = 0.005$; Mann–Whitney $z = 1.6178$, *ns*; see Figure 3). The TD group performed basically at ceiling and rarely omitted verbs. Despite this difference across groups, a Tukey–Kramer multiple comparison test showed no difference in verb production accuracy for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

Similarly, individuals with DS produced significantly fewer elements of obligatory argument structure (DS, $M = 0.71$, $SD = 0.33$; TD, $M = 0.99$, $SD = 0.003$; Mann–Whitney $z = 2.8113$, $p = .005$; large effect size, $d = 1.27$). This difference was present in both two-place (DS, $M = 0.57$, $SD = 0.46$; TD, $M = 0.98$, $SD = 0.002$; Mann–Whitney $z = 2.1051$, $p = .035$; large effect size, $d = 1.35$) and three-place verbs (DS, $M = 0.71$, $SD = 0.32$; TD, $M = 0.98$, $SD = 0.006$; Mann–Whitney $z = 2.5126$, $p = .012$, large effect size, $d = 1.26$), although not in one-place verbs (DS, $M = 0.85$, $SD = 0.33$; TD, $M = 1$, $SD = 0$; Mann–Whitney $Z = 1.7669$, *ns*; see Figure 4). The DS group was more likely to omit obligatory elements of argument structure than the TD group in target sentences containing two-place and three-place verbs, whereas omission was rarely seen in responses from the TD group. However, as in the verb production results, a Tukey–Kramer multiple comparison test showed no difference in verb production accuracy for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

Figure 3. Obligatory verb use in narratives. $^*p = .03$. $^{**}p = .005$.

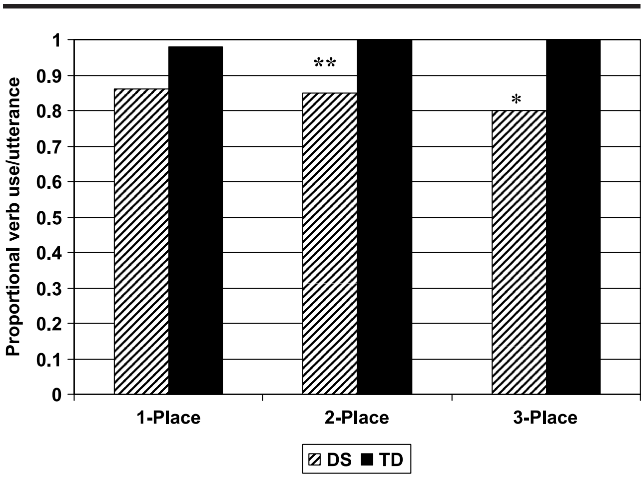
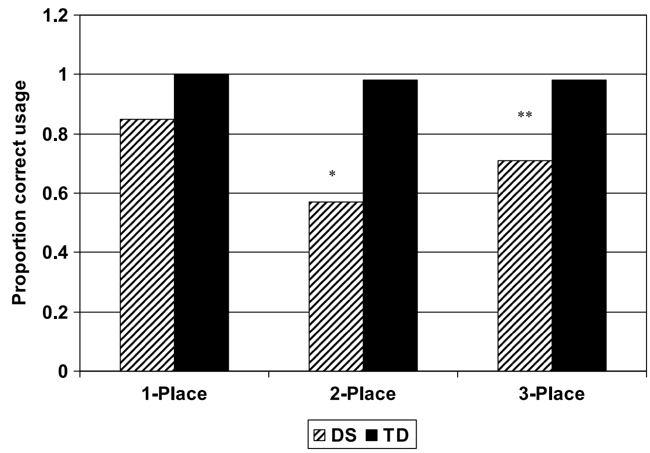
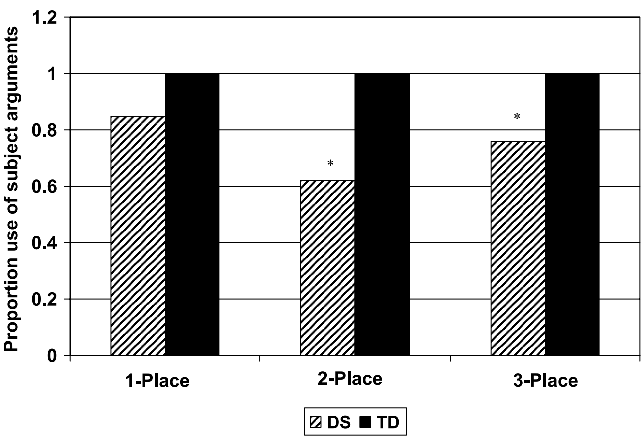


Figure 4. Proportion of correct verb use by verb type. $^*p = .035$. $^{**}p = .012$.



The narrative task may be overestimating participants' performance somewhat because some of the two-place and three-place verbs had optional arguments; these items were marked as accurate with only the required arguments present. On the other hand, those verbs with more nonoptional arguments also provide more opportunities to omit necessary elements, which could result in poorer accuracy for a relatively trivial reason. To further explore whether this was the case, production of subject arguments (which are required in all verb types, one-place, two-place, and three-place verbs) was analyzed for all verbs and by verb type. There was a significant difference between the DS and TD groups on percentage of all target verbs with subject arguments (DS, $M = 0.74$, $SD = 0.34$; TD, $M = 1$, $SD = 0$; Mann–Whitney $z = 2.7872$, $p = .005$), with the DS group significantly more likely to omit subject arguments, a behavior never observed in the TD group. Effect size was large ($d = 1.16$). This was present in both two-place (DS, $M = 0.62$, $SD = 0.44$; TD, $M = 1$, $SD = 0$; Mann–Whitney $z = 2.4606$, $p = .014$, large effect size, $d = 1.28$) and three-place verbs with subject arguments (DS, $M = 0.76$, $SD = 0.33$; TD, $M = 1$, $SD = 0$; Mann–Whitney $z = 2.4585$, $p = .014$, large effect size, $d = 1.10$) but not in one-place verbs (DS, $M = 0.85$, $SD = 0.33$; TD, $M = 1$, $SD = 0$, Mann–Whitney $z = 1.7669$, *ns*; see Figure 5). This suggests that the difference between groups in the verbs requiring more argument structures was not simply the result of there being more opportunities for errors in these verbs. However, as before, no significant differences were found between subject-production accuracy

Figure 5. Proportion of subject arguments included. *p = .014.



in narratives for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

Summary, verb, and argument structure. In general, individuals with DS made more errors than their vocabulary-matched peers on both two-place and three-place verbs but not on one-place verbs. They were more likely to omit verbs and verb arguments than the control participants, particularly as the number of arguments increased. They also occasionally omitted subject arguments, a behavior not seen in the TD participants.

Predictors

The participants with DS represented a wide range of ages (11;11–32;10), and they had a wide range of memory skills. To explore whether performance varied as a function of these factors, we calculated correlations between language tasks and both age and memory skills. Within the DS group, no significant correlations were found between age and grammaticality judgment accuracy, verb-naming accuracy, or subject-production accuracy (age grammaticality, $\rho = -.276$, $p = .47$; age–verb accuracy, $\rho = -.235$, $p = .54$; age–subject accuracy, $\rho = -.067$, $p = .86$; all *ns*). Performance on the sentence memory task was highly correlated to verb production accuracy ($r = .62$, $p = .006$), argument structure accuracy ($r = .75$, $p = .0004$), and subject-production accuracy ($r = .74$, $p = .0005$) across participants. Thus, language-production accuracy may be tied to working memory ability.

Discussion

This study investigated the ability to retrieve and comprehend verbs and elements of argument structure in individuals with DS compared with typically developing children of comparable receptive vocabulary abilities. It also investigated memory skills in these two populations. In both domains, individuals with DS showed deficits that were specific to situations that involve syntactic processing.

Participants were tested in six different memory tasks, differing in the type of information to be retained and the type of response to be given. Relatively successful retrieval of visual information, namely the spatial-memory task that requires a nonverbal response, was consistent with previous findings that indicated that individuals with DS are not impaired relative to individuals who are learning disabled, but without DS on tasks that rely on storage, retention, and retrieval of visual information (Bower & Hayes, 1994; Chapman, 2006; Rowe et al., 2006), nor impaired relative to children who are TD, as indicated by this study. However, contrary to previous findings (Bower & Hayes, 1994; Chapman, 2006; Rowe et al., 2006), individuals with DS also performed similarly to vocabulary-age matched individuals who are TD when asked to repeat digits and words. Matching procedures (e.g., use of the Stanford–Binet, age, nonverbal IQ, alternative measure of vocabulary skills, respectively) may account for the differences that we observed. It was only when the element of grammar was introduced, in the sentence memory task, that the individuals with DS performed significantly worse than the TD control group. This may imply that individuals with DS do not necessarily have impaired memory skills when compared with individuals who are TD of comparable language age but that grammatical processing affects the ability for individuals with DS to store, retain, and retrieve verbal information. Sentence-repetition tasks are often used in language assessment specifically because they appear to require re-encoding of the stimuli through the speaker's internal grammatical rules. This finding reinforces the theory of a specific deficit in expressive grammar (syntax) in individuals with DS (Chapman et al., 1998; Chapman & Hesketh, 2000; Vicari et al., 2000).

It was predicted that individuals with DS would exhibit a deficit in retrieval of verbs and elements of argument structure, while remaining relatively unimpaired in comprehension of verbs in isolation and grammatical rules of argument structure in sentences. It was also predicted that this verb deficit would be more apparent as the number of arguments associated with a verb increased. Results indicate that individuals with DS do display a specific deficit in verb and argument structure retrieval that varies as a function of verb type (one place, two place, and three place).

The individuals with DS did not differ significantly from the individuals who are TD in comprehension of isolated nouns or verbs, as predicted. However, contrary to predicted results, the individuals with DS also did not differ significantly from the individuals who are TD in naming of single nouns or verbs. Both groups had difficulty retrieving verbs to label stimulus pictures. The wide difference in ages between the DS and TD groups may explain the similarity in performance on this task. Although the group with DS may have a specific difficulty retrieving verbs, the group who is TD may not have the same level of exposure to verbs as the group with DS, causing the gap between the verb retrieval skills of the groups to remain relatively small and statistically insignificant. Although statistically insignificant, there was a trend for the group with DS to perform worse than the group that is TD on verb-naming accuracy for one-place, two-place, and three-place verbs, and this difference increased as the number of arguments associated with the verbs increased.

It was predicted that the individuals with DS and the individuals who are TD would perform similarly on the grammaticality judgment task, indicating that both groups have similar understanding of the grammatical rules that govern argument structure. However, the individuals with DS performed significantly worse than the individuals who are TD on this task, and in fact they performed at near-chance level. Observation suggests that individuals with DS often appeared to guess on this task and also often seemed to misinterpret task instructions, despite passing practice items. Individuals with DS often responded that the sentence had good grammar if the content was good and bad grammar if the content was bad. For example, an individual with DS responded that the sentence, "*The girl is spilling the milk in the kitchen.*" was a bad sentence because spilling is bad. Although some individuals who are TD were noted to interpret the task in this way as well, it was much more common in the individuals with DS. It is difficult to know whether misinterpretation of task instructions or impaired comprehension of argument structure contributed more to the poor performance on this task by individuals with DS.

A specific deficit in verb retrieval in individuals with DS was apparent in the narrative task. Individuals with DS were significantly more likely to omit verbs in target sentences than individuals who are TD. Furthermore, when target sentences were broken down into target one-place, two-place, and three-place verb sentences, individuals with DS omitted verbs significantly more often in target two-place and three-place verb sentences but not in one-place verb sentences. This supports the notion that individuals with DS not only have a specific deficit in verb retrieval but also that it is affected by how many arguments are associated with a verb. Specifically, the more arguments that are associated with a verb, the more difficult it is to retrieve. This is especially interesting because verb retrieval in individuals with DS seems to be affected by the number of arguments associated with that verb despite the optionality of those arguments.

Accuracy of argument structure retrieval is also impaired in individuals with DS. Individuals with DS are significantly more likely to produce verbs with incorrect argument structure, specifically two-place and three-place verbs. Although there are more opportunities for omission of elements of argument structure as the number of arguments associated with a verb increases, there is evidence that the effect of verb type (one-place, two-place, or three-place verbs) on ability to retrieve verbs and their argument structure goes beyond this probability effect. The TD participants did not have difficulty retrieving elements of argument structure, regardless of verb type, at near 100% accuracy, despite their young age compared with the DS participants. In addition, the probability effect is somewhat minimized by the inclusion of optional two- and three-place verbs, most of which only require a subject argument. Effects of verb type on verb and argument structure retrieval in individuals with DS compared with individuals who are TD, despite the optionality of arguments, strengthens the interpretation that individuals with DS demonstrate a specific verb-retrieval deficit that is influenced by the number of arguments associated with a verb.

Perhaps the most interesting and compelling evidence of the effect of verb type on argument structure retrieval is the significant difference between DS and individuals who are TD in subject-argument production. Individuals with DS were significantly more likely to omit subjects in sentences with two-place and three-place verbs than individuals who are TD, but this difference was not found in sentences with one-place verbs. Despite the obligatory nature of the subject argument in all stimulus sentences, and all English sentences with the exception of imperatives, this difference was only found in those sentences that require verbs associated with more arguments (two-place and three-place verbs). One possible theory is that as the number of arguments associated with a verb increases, so does sentence processing difficulty; to reduce demands on the language system, individuals with DS "opt" to eliminate the subject because it is most easily recovered from the context that was provided in the elicitation task.

This study found that individuals with DS have a specific deficit in verb retrieval compared with individuals who are TD matched for receptive vocabulary age, which was most apparent in omission of verbs in narrative productions. This is consistent with prior work also finding verb-production deficits in individuals with DS. It was also found that verb and argument structure retrieval is affected by the number of arguments associated with that verb, as indicated by omission of two-place and three-place verbs and arguments (viz., subject arguments) in narrative productions (as compared with one-place verbs). Verb retrieval in isolation was not significantly impaired in individuals with DS, but there was a trend for individuals with DS to label verbs less accurately than individuals who are TD, and this trend was more apparent as the number of arguments associated with a verb increased. Individuals with DS had significantly poorer comprehension of argument structure than individuals who are TD as measured by a grammaticality judgment task; however, it is suspected that comprehension of task instructions had an effect on the performance of some individuals with DS. Single-word comprehension for nouns and verbs did not differentiate the DS and TD groups.

Sentence memory was highly correlated with several measures of performance on the narrative task (verb-production accuracy, argument-structure accuracy, and subject-production accuracy). A specific deficit in sentence memory, which was apparent in the individuals with DS, could have contributed to poor performance on the narrative task. However, the mean number of words per target sentence was similar across verb type (i.e., within one word from one another), suggesting that verb type contributed to significant differences in performance rather than sentence length alone.

Similarly, although it is possible that verb frequency played a role in the performance profiles that we observed, our stimulus sets were balanced for this factor, as well as phonological neighborhood density and phonotactic probability. That differences in performance were detected as argument structure increased, with these other factors held constant, suggests that our findings were not primarily the result of word frequency characteristics of our stimulus set.

We do recognize that our sample of participants was relatively small and somewhat heterogeneous in profile on some tasks. However, that we observed large effect sizes for those statistical findings suggestive of a verb retrieval deficit in our sample of individuals with DS can serve as support for the continued investigation of syntactic abilities in this population, using larger samples and additional tasks.

In addition, although we originally matched our participants by receptive vocabulary ability, we knew that their performance on our more general language production tasks, such as the narrative, might differ quite broadly. As noted earlier in our discussion of the narrative analyses, although the individuals with DS produced narratives with fewer words and with shorter mean length of utterance measured in words, these differences failed to reach statistical significance, suggesting that our matching process had identified groups of participants broadly equivalent in expressive language skills.

Directions for Future Research

This study supplements previous studies, indicating that individuals with DS have a fairly specific deficit in expressive syntax. It also strengthens the theory that this deficit may stem, at least in part, from a specific deficit in verb and argument structure retrieval, which, in turn, may be influenced by the number of arguments associated with a verb. It would be desirable to analyze verb and argument structure retrieval in structured and unstructured narrative and conversational language samples within the same population of participants that would more closely mirror everyday language use by individuals with DS. In addition, it would be interesting to further examine subject omission in individuals with DS in structured and unstructured language samples and how this pattern might relate to verb and argument structure retrieval and processing and expressive grammar deficits, as well as strategies that DS speakers appear to use when demands for formulation exceed their production capacity. Many studies are either naturalistic or experimental; we may profit from a combination of such tasks within the same samples. A longitudinal study following individuals with DS from a young age would be worthwhile to investigate the development of verb and argument structure production in this population.

It is unclear whether an impairment in verb and argument structure retrieval in individuals with DS reflects a poorly organized lexicon, incomplete entries in the lexicon, or difficulty accessing entries in the lexicon. Replication of tasks within a group of individuals with DS would allow examination of the consistency of verb and argument structure retrieval. If individuals with DS are consistent in their ability to retrieve verbs and their arguments, it may indicate that there is a breakdown in the organization or quality of representations of these entries. However, if verb and argument structure retrieval is inconsistent, it may reflect a breakdown in access rather than storage of verb entries.

There is a need for more research in the language of people with DS, particularly on adults, considering its relatively wide prevalence. This study negates the notion that there is a generalized depression in language ability that is predicted by cognitive skills in persons with DS. The discrepancy between language and cognitive scores supports the view that individuals with DS are able to continue to master language skills well into their adult years. Understanding how language develops in individuals with DS should lead to more effective methods of improving language and communication skills in this population.

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Appendix A. Noun and verb list.

Verb	Frequency	% Noun Usage	Noun	Frequency	% Verb Usage
Obligatory One-Place (Ob1)					
bark	1	92.9	kite	1	0
crawl	37	9.8	belt	36	7.7
cry	64	35.4	hat	71	0
jump	58	14.7	moon	63	1.6
laugh	89	19.8	box	82	4.7
pray	30	0	shirt	29	0
run	431	17.9	church	451	0
sit	314	0	door	348	0
sneeze	3	0	pear	8	0
snore	4	0	vest	4	0
swim	55	1.8	shoe	58	3.3
wink	18	18.2	axe	19	0
Obligatory Two-Place (Ob2)					
carry	304	0	foot	361	0.6
erase	5	0	carrot	5	0
pull	145	8.2	gun	142	1.4
spill	9	0	stool	8	0
stir	39	0	corn	38	0
weigh	33	0	boot	30	11.8
zip	2	0	goat	8	0
Optional Two-Place (Op2)					
climb	65	3.0	nose	65	3.0
ride	126	14.3	window	172	0
shave	23	0	bell	23	0
sweep	54	12.9	star	58	6.5
watch	209	12.9	arm	217	21.9
Obligatory three place (Ob3)					
give	1264	0.15	hand	717	6.8
put	513	0	house	662	7.4
Optional three place (Op3)					
bake	15	0	rabbit	16	0
build	249	0.8	table	242	0.4
cut	245	14	heart	199	0
fry	143	3.4	glass	128	0
knit	18	11	grapes	10	0
pour	48	0	bus	42	0
read	274	0	book	292	2.3
sew	18	0	pie	19	0
throw	150	4.5	tree	160	0
write	561	0	eye	524	2.4
M (SD)	165.4 (264.5)			147.7 (181.1)	

Note. This word list is reprinted from Kim and Thompson (2000, 2004).

Appendix B. Examples of grammaticality judgment sentences.

A. Grammatical sentences with basic argument structure
- The dog is barking.
- The boy is carrying the box.
- The woman is giving the money to the girl.

B. Grammatical sentences with an additional adjunct
- The baby is crawling in the house. (+locative)
- The man is carrying the box to the car. (+locative)
- The woman is giving the money to the girl in the car. (+locative)

C. Ungrammatical sentences with omission of argument(s)
- The boy is carrying. (–NP)
- The woman is giving to the driver (–NP)
- The boy is carrying in the park (–NP) (+locative)
- The man is putting the book at night. (–PP) (+temporal)

D. Ungrammatical sentences with addition of an illegal argument
- The boy is sneezing the girl.
- The boy is erasing her the chalkboard.
- The girl is stirring the man the soup.

Note. Adapted from Kim and Thompson (2004). NP = noun phrase; PP = prepositional phrase.

Appendix C. Narrative examples.

1. The Pool (one place)
   a. It is sunny at the pool.
   b. **A boy *runs* in the grass.**
   c. **A girl *jumps* from the diving board.**
   d. **A boy *swims* in the pool.**
2. Joey (two place)
   a. Joey is helping the teacher.
   b. **He *carries* the teacher's books.**
   c. **He *erases* the chalkboard.**
   d. **He *sweeps* the floor.**
3. Hungry (three place)
   a. Mary is hungry.
   b. **She *fries* eggs on the stove.**
   c. **She *bakes* cookies in the oven.**
   d. **Mary *gives* a cookie to her friend.**

Note. Target sentences appear in boldface. Target verbs appear in italics.