

ABSTRACT

Title of Document: VERB COMPREHENSION AND USE IN
DOWN SYNDROME.

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This study examined verb and argument structure retrieval in 18 individuals, nine with Down syndrome (DS), ages 11 years, 11 months (11;11) to 32;10 and nine language age-matched typically-developing (TD) children ages 3;2 to 13;6. It was hypothesized that individuals with DS would exhibit a specific deficit in verb and argument structure retrieval. Results from verb and noun comprehension tasks, verb and noun naming tasks, grammaticality judgments, and narrative tasks were compared between groups. Neither single verb comprehension nor single verb naming differentiated the DS and TD groups. Individuals with DS performed significantly worse than TD individuals when asked to judge sentence grammaticality. Individuals with DS omitted verbs in elicited narratives significantly more often than TD individuals, specifically when productions of two-place and three-place verbs were attempted. Individuals with DS also omitted other necessary elements of argument structure, such as subjects, in sentences containing two-place and three-place verbs significantly more often than TD individuals.

VERB COMPREHENSION AND USE IN DOWN SYNDROME

By

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Arts
2009

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Introduction

Down Syndrome

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). Perceptible physical abnormalities vary between individual cases and may include retarded growth, a flattened facial profile, small and low-set ears, epicanthic folds (a skin fold in which the upper eyelid covers the inner corner of the eye), a fissured and thickened tongue, and disorders of dentition (Korenberg et al., 1994).

Down syndrome causes delays in the way a child develops, mentally as well as physically. Some individuals with DS require frequent medical attention, while others lead relatively healthy lives (Korenberg, et al., 1994; Miller, Leddy, & Leavitt, 1999). The most common medical complications in children with DS include cardiac anomalies and gastrointestinal diseases (Korenberg, et al., 1994; van Trotsenburg, Heymans, Tijssen, de Vijlder, & Vulsma, 2006). Obesity, hypothyroidism, and celiac disease are more common in adults with DS than typical adults (Henderson, Lynch, Wilkinson, & Hunter, 2006). Down syndrome is the most common syndrome resulting in mental retardation (Miller et al., 1999).

Cognitive Deficits in Down Syndrome

Most individuals with DS are cognitively impaired. A specific well-documented deficit lies in verbal short-term memory (Bower & Hayes, 1994; Chapman, 2006; Laws, 2004). Individuals with DS perform more poorly than TD

individuals when asked to repeat digits and nonwords (Rowe, Lavender, & Turk, 2006). They also perform worse than learning-disabled, non-DS individuals when asked to repeat digits, sentences, and nonwords (Bower & Hayes, 1994; Chapman, 2006; Rowe, Lavender, & Turk, 2006). It is well known that individuals with DS have difficulty storing, retaining, and retrieving verbal information. However, individuals with DS perform as well or better than learning-disabled, non-DS individuals on tasks that rely on storing, retaining, and retrieving visual information (Bower & Hayes, 1994; Chapman, 2006; Rowe, Lavender, & Turk, 2006). For example, individuals with DS and non-DS, learning-disabled individuals perform similarly when asked to observe and mimic an experimenter tapping a sequence of blocks (Rowe, Lavender, & Turk, 2006).

Cognitive deficits in DS also include attention and problem solving (Krakow & Kopp, 1983; Rowe, Lavender, & Turk, 2006). For example, individuals with DS are less efficient than learning-disabled, non-DS individuals when asked to search for and cross out target symbols on a sheet containing target and distractor symbols (Rowe, Lavender, & Turk, 2006). They take more time and make more mistakes during this task, indicating that their sustained attention is impaired. Children with DS also spend more time unoccupied in free-play situations than typically-developing children, signifying an impairment in sustained attention (Krakow & Kopp, 1983). Individuals with DS also show a decreased ability to sort symbols across two dimensions (shape and color), indicating a deficit in alternating attention (Rowe, Lavender, & Turk, 2006). Planning and problem solving are also areas of difficulty for individuals with DS (Das & Mishra, 1995; Rowe, Lavender, & Turk, 2006).

Language and Down Syndrome

Difficulty with the acquisition and use of language in individuals with DS has been well-documented (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). Deficits in all three linguistic domains, phonology (speech sound system), semantics (meaning in communication), and syntax (grammar) have been noted in the population (see Chapman, 1999; Chapman, 2003; Chapman & Hesketh, 2000 for reviews). A brief overview is provided in the following sections.

Phonology

Most individuals with DS are delayed in acquiring phonological skills, particularly articulation of speech sounds (Hamilton, 1993; Rosin, Swift, Bless, & Vetter, 1988). Increased tongue-palate contact during production of several consonants (e.g., /t/, /d/, /n/, /l/) has been noted in individuals with DS, which may contribute to decreased intelligibility (Hamilton, 1993). Individuals with DS produce significantly fewer consonants correctly compared to non-DS individuals with cognitive impairment (Rosin et al., 1988). Perhaps because of facilitating contextual cues in conversations that are absent in other speaking tasks, intelligibility is better in conversation than in narratives (Chapman et al., 1998).

Several factors may contribute to articulation difficulties in individuals with DS. First, they have difficulty planning and coordinating the quick and precise tongue movements necessary to speak clearly (Hamilton, 1993). They may also

demonstrate significant hypotonia (low muscle tone and reduced muscle strength) (Hamilton, 1993). Individuals with DS also are at high risk to have concomitant hearing impairment, which may contribute to their ability to monitor and produce speech sounds accurately (Laws, 2004). In sum, individuals with DS often have impaired articulation, which may result from numerous physiological factors.

Semantics

Individuals with DS perform similarly to TD children with comparable cognitive abilities (mental ages) on sentence and vocabulary comprehension tasks (Chapman et al., 1998; Ypsilanti, Grouios, Alevriadou, & Tsapkini, 2005). That is, individuals with DS perform as well as would be predicted by their intelligence on tasks requiring them to identify pictures matching verbally-presented words and sentences. However, when asked to define vocabulary, individuals with DS perform significantly more poorly than their cognitive matches (Ypsilanti et al., 2005). Thus, expressing knowledge about stored vocabulary is an area of weakness for individuals with DS. However, vocabulary skills (both receptive and expressive) show a more rapid developmental course than do grammatical/syntactic skills in DS, and in some cases receptive vocabulary skills have been noted to surpass levels predicted by cognitive abilities (Chapman et al., 1998).

Syntax

Individuals with DS exhibit impaired expressive syntax in narration, conversation, and in structured repetition tasks (Chapman et al., 1998). Omission of sentence elements and morphological errors (such as tense and plural formation

errors) are also seen in sentence repetition tasks, in which the child is instructed to repeat model sentences back to the examiner (Caselli et al., 2008; Eadie et al., 2002; Vicari, Caselli, & Tonucci, 2000; Ypsilanti et al., 2005). It is not clear whether such problems reflect a lack of knowledge or a lack of sufficient cognitive resources during performance tasks. Both are likely to be involved. For example, impaired memory and attention could potentially have negative effects both on the ability to acquire as well as use syntactic skills.

Relationship Between Cognition and Language

General levels of language development in DS can be fairly accurately predicted by measures of nonverbal mental age, such as the ability to perceive, retain, and analyze information (Adams & Gathercole, 2000). In TD children, superior performance on non-word repetition tasks is related to higher MLU and a greater range of syntactic constructions (Adams & Gathercole, 2000). In children with expressive specific language impairment (SLI), non-word repetition is impaired (Conti-Ramsden, 2003; Munson, Kurtz, & Windsor, 2005), suggesting that this task taps important predictors or bases of language skill.

One question is whether the language deficits observed in individuals with DS are purely a result of cognitive deficits, or whether their language deficits exceed what would be expected from the cognitive deficits alone. Several studies have attempted to address this issue by comparing language skills of individuals with DS to individuals of comparable nonverbal mental age (Chapman & Hesketh, 2000; Chapman, Schwartz, & Kay Raining-Bird, 1991; Chapman et al., 1998; Vicari et al., 2000). Individuals with DS comprehend words and sentences at the same level, or in

some cases, better than individuals matched for nonverbal mental age (Chapman, et al., 1991, 1998). However, some language abilities lag behind nonverbal reasoning skills. In particular, and as noted above, individuals with DS demonstrate poorer expressive syntax than individuals matched for mental age (Chapman & Hesketh, 2000; Chapman et al., 1998; Vicari et al., 2000).

Syntax and Verbs in Down Syndrome

As noted, syntax is a particularly difficult area of language for individuals with DS. Mean length of utterance (MLU) is reduced in individuals with DS, even when compared to their mental-age matches (Chapman & Hesketh, 2000; Chapman, et al., 1998; Vicari et al., 2000). Their language has been described as telegraphic, with many words missing (Vicari et al., 2000). Omission of sentence elements occurs during conversation, narrative, and phrase repetition tasks (Caselli et al., 2008; Eadie et al., 2002; Vicari et al., 2000; Ypsilanti et al., 2005). Individuals with DS omit many more major sentence elements than do their mental-age matches, particularly verbs (Caselli et al., 2008; Hesketh & Chapman, 1998). For example, when asked what one does during free time, an individual with DS might respond “cookies”, while a TD individual might say, “(I) bake cookies.”

Both main verbs as well as auxiliary verbs are likely to be omitted. However, individuals with DS do not produce significantly fewer different verbs, and in fact, produce a significantly greater variety of main verbs than do TD individuals 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, but that these entries are not accessed well during production tasks. This hypothesis

is supported by the fact that individuals with DS perform similarly to typical nonverbal mental age matches on verb comprehension tasks (Chapman, Schwartz, Kay-Raining Bird, 1991, Ypsilanti et al., 2005).

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 either in omission of 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). Additionally, 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 individuals with acquired brain damage, such as those with agrammatic aphasia. The language of agrammatic aphasic individuals who, like individuals with DS, exhibit reduced MLU and omission of verbs and other syntactic elements, has been noted to be influenced by argument structure (Kim & Thompson, 2000; Kim & Thompson, 2004). In a pair of studies, Kim and Thompson investigated the relationship between verb retrieval and verb argument structure properties in agrammatic aphasic persons. Most of their participants completed grammatical judgment tasks with above 90% accuracy, suggesting that comprehension of verb argument structure properties is unimpaired in this population. Additionally, no significant differences were found between comprehension of nouns and verbs.

In contrast, differences emerged when noun and verb production was examined using a picture-naming task (Kim & Thompson, 2000, 2004). The aphasic individuals performed significantly worse when naming verbs compared to nouns. Furthermore, three-place verbs were named incorrectly significantly more often than two-place verbs, which were named incorrectly significantly more often than one-place verbs.

A narrative task was developed to examine the use of each verb type and their respective argument structures in the patients' spontaneous speech. The aphasic individuals produced one-place verbs with correct argument structure significantly more often than the other two types. These findings suggest that agrammatic aphasic individuals' ability to access verbs is influenced by the number of arguments associated with the verb. This held 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 expressive language of agrammatic aphasic patients mirrors patterns found in individuals with DS- a syntactic impairment involving verb retrieval, resulting in reduced MLU and ungrammatical sentences. This suggests the possibility that the language production of individuals with DS may also be affected by argument structure. However, Grela (2003) found no differences in the omission of subject arguments as a function of the argument structure of the verb in individuals with DS. Transcripts taken from a database of child-caretaker interactions were analyzed 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 typical children as a function of verb category or argument position for one and two-place verbs. Since the children did not produce any three-place verbs, these were not included in the analysis.

In order to investigate the effect of one-, two-, and three-place verbs on verb retrieval, comprehension, and production, a more structured experiment is required.

In conversation or narrative, 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. In addition, it is important to evaluate verb comprehension and access separately, to identify where a potential deficit may lie.

Hypotheses

This study seeks to address the following research questions:

Verb Processing and Production

1. Do individuals with DS differ in their verb processing and production profiles from those seen in language age-matched unimpaired individuals?

More specifically,

- a. Is there a difference in the ability to name verbs? This question requires comparison with the ability to retrieve nouns, to distinguish between impaired word retrieval in general, or a specific deficit in verb retrieval. It is hypothesized that the individuals with DS will make significantly more errors in verb naming and will take significantly longer to retrieve verbs when compared to noun retrieval.
- b. Is there a difference in verb comprehension? Past work suggests that the deficit in DS is one of access, rather than representation.

Thus, it is hypothesized that the individuals with DS will comprehend verbs as accurately as nouns, and will perform on both tasks as well as do language age-matched comparison participants.

- c. Do verb production deficits in DS reflect underlying problems with argument structure representation? If so, will this be reflected on grammaticality judgment tasks? It is hypothesized that the individuals with DS and comparison participants will complete the grammaticality judgment task with similar accuracy.
- d. Is verb retrieval impaired in a narrative task? It is hypothesized that the individuals with DS will produce significantly fewer verbs than the typical comparison participants during elicited narratives.

Verb and Argument Structure Processing and Production

- 2. Do individuals with DS differ in their verb and argument structure processing and production from language-age-matched unimpaired individuals as a function of verb type (i.e., one, two, and three-place verbs)? More specifically,
 - a. Will verb type affect picture-naming ability in individuals with DS? We predict that individuals with DS will make more errors and take longer to name three-place verbs than two-place verbs, and that two-place verbs will pose more difficulty than one-place verbs. It is expected that the individuals with DS will be more

affected by verb type (i.e., perform worse as the number of arguments associated with a verb increases) than the control group.

b. Will verb type impact verb production in individuals with DS?

Individuals with DS are expected to omit verbs and their obligatory argument structure more often as the number of arguments associated with a verb increases. This pattern may also be reflected in the control participants (it is more likely to omit an argument when there are three arguments available to omit than when there is one), but the difference is expected to be greater in the individuals with DS.

Summary

This study investigates verb retrieval in individuals with DS compared to individuals of comparable language age, and asks whether the complexity of argument structure affects verb access, comprehension, and production. To answer these questions, tasks modeled on those used by Kim and Thompson (2000, 2004) will be used. The results of all tasks will be compared with TD individuals of comparable language age, to investigate whether performance on language tasks can be accounted for by language age. Past research in DS has questioned whether language profiles are specific to impaired language representation or access, or reflect more general cognitive deficits. Therefore, memory skills will also be appraised in the two participant groups. Three memory tasks requiring a nonverbal response (i.e., pointing), and three memory tasks requiring a verbal response will be administered.

Because of their reported language profiles, it is hypothesized that the individuals with DS will perform similarly to the control group on memory tasks requiring a nonverbal response, and that the individuals with DS will exhibit poorer performance than the control group on memory tasks requiring a verbal response.

If these predicted results are found, it would indicate that individuals with DS have a specific verb access impairment (rather than a general access impairment involving verbs and nouns, or an impairment in verb or argument structure comprehension) that is further exacerbated as the number of arguments associated with that verb increases.

These findings would suggest that decreased MLU, impaired expressive syntax, and omission of verbs and other sentence elements might be related to difficulty efficiently and accurately retrieving verbs and their argument structure. Thus, individuals with DS may benefit from intervention targeted at strengthening their ability to access verbs and their argument structure in an effort to improve expressive syntax.

Methods

Participants

Participants were nine individuals with DS and nine TD children. The individuals with DS were recruited through local county groups and organizations for parents with children who have DS and for older individuals with DS (e.g., Down Syndrome Network of Montgomery County, The Arc of Montgomery County, Center for Handicapped Individuals). The TD children were recruited through the same local county organizations for parents and individuals with DS, and through a database at the University of Maryland intended for families who wish to be contacted to participate in research. All participants who answered the call for subjects were given the *Peabody Picture Vocabulary Test- Fourth Edition (PPVT-IV)* (Dunn & Dunn, 2007) in order to make pair-wise matches for language age. TD individuals were considered a match for an individual with DS if they were the same gender and had a *PPVT-IV* raw score within five points of the score of the individual with DS. A total of 19 individuals with DS participated in the experiment. Four of these participants were excluded from analysis due to substantial (> 50%) exposure to a second language from a young age. Two participants with DS were excluded from analysis due to failing the hearing screening at all frequencies, at both 40dB and 20dB, in both ears. One participant with DS was excluded from analysis due to a notably low raw score on the *PPVT-IV* (Dunn & Dunn, 2007) (58), for which a typically-developing match would have been too young to participate in this study (i.e., under three years old). Of the 12 remaining participants with DS, nine were successfully matched to

typically-developing children for gender and *PPVT-IV* (Dunn & Dunn, 2007) raw score. Only those participants with DS for whom a match was successfully recruited were included in the final analysis.

This procedure yielded the 18 final participants. The individuals with DS had a mean *PPVT-IV* raw score of 112.9 (range: 74-183) and the TD individuals had a mean *PPVT-IV* raw score of 114.9 (range: 73-185). These *PPVT-IV* raw scores are not statistically different from each other (See Figure 1). The individuals with DS ranged in age from 11 years, 11 months (11;11) to 32;10, with a mean age of 18.9 years. As might be expected, the control group individuals were considerably younger and ranged 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.

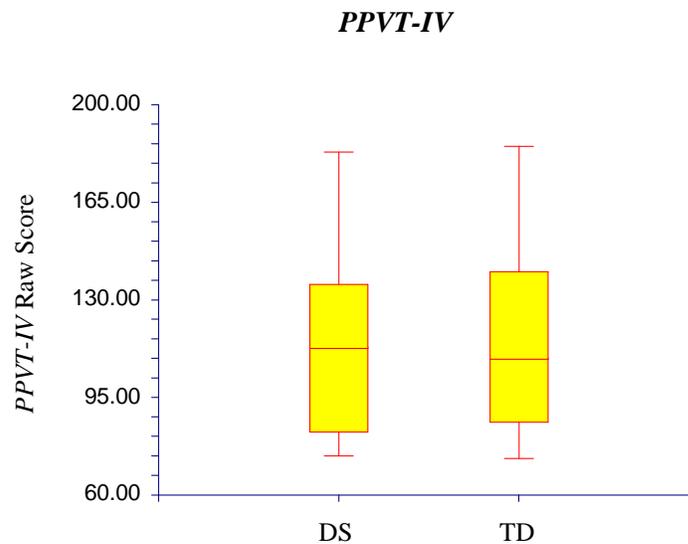


Figure 1. *PPVT-IV* raw scores (mean, spread, and interquartile range)

Participants' hearing was evaluated using a pure-tone audiometric screening test at 500, 1000, and 2000 Hz at 20dB and 40dB to confirm adequate ability to hear all experimental instructions and stimuli. All participants passed the screening at all frequencies at 40dB, and all but two individuals with DS passed the screening at all frequencies at 20dB. One of the individuals with DS who did not pass the screening at 20dB in the right ear wore a hearing aid in that ear during all other experimental tasks, which was not worn during the hearing screening. A recent audiogram for this individual indicated that when wearing the hearing aid, thresholds at the screening frequencies were elevated to at least 25dB. The other individual with DS who did not pass the screening at 20dB failed at 1000 and 4000 Hz in his left ear, but passed at all frequencies in the right ear. Because both participants had normal hearing unilaterally, they were judged by the experimenter to have adequate hearing to participate in this study.

Participant Characteristics

Pair No.	DS Participants- Age	TD Participants- Age	Gender
1	16;0	13;6	F
2	17;0	5;2	F
3	19;4	6;6	M
4	15;1	4;5	F
5	32;10	7;10	M
6	11;11	3;2	F
7	24;0	3;4	F
8	17;4	5;0	M
9	16;8	5;7	M

Table 1. Participant (matched pairs) ages and genders

Stimuli and Procedures

Testing was completed during two sessions for all participants. The first session consisted of the *PPVT-IV* (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 requiring 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 one hour. Task order was fixed for all participants and followed the order listed above for each session. 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.

PPVT-IV

The *PPVT-IV* (Dunn & Dunn, 2007) is a standardized test of receptive vocabulary intended for use in individuals from 2;6 to 90;0. Examinees are asked to point to a picture representing a stimulus word provided verbally by the examiner while presented with four full-color illustrations. Administration lasted approximately 10-15 minutes for each participant.

Memory

Nonverbal Response Tasks

Three memory tasks requiring nonverbal response were administered to each participant: a digit span task, a word span task, and a spatial memory task, developed for the assessment of verbal and non-verbal short-term memory in brain-damaged

patients (De Renzi & Nichelli, 1975). For the digit span task, participants were provided with digit strings of increasing length, presented verbally. After each string, participants were provided with a piece of paper with the stimulus digits 1-9 arranged randomly in a 3 x 3 design. All participants were provided with the same digit arrangement. Participants were asked to point to the digits they heard in the same order they heard them after each string. Similarly, during the word span task, participants were provided with word strings of increasing length (e.g., bread-cup-ladder), presented verbally. After each string, participants were provided with a piece of paper with 9 stimulus pictures arranged randomly in a 3 x 3 design. All participants were provided with the same picture arrangement. Participants were asked to point to the pictures that represented the words they heard in the same order they heard them after each string was presented. For the spatial memory task, the same material used in the digit span task was used. Participants were instructed to point to the same strings of numbers that the examiner pointed to in the same order, and were presented with strings of increasing length.

All participants were provided with two practice strings at the beginning of each task. For all three tasks, pairs of strings of increasing length were presented (i.e., two two-item strings, two 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 of strings. Participants were required to pass admission criteria for each nonverbal memory task in order to participate. All participants passed admission criteria for all nonverbal memory tasks, except for two individuals with

DS, who failed admission criteria for the digit span task, and therefore did not participate in that task. Administration for all three nonverbal memory tasks lasted approximately 10-15 minutes for each participant.

Verbal Response Tasks

Three memory tasks requiring verbal response were administered to each participant: a digit span task, a word span task, and a sentence repetition task. All three tasks were taken from the *Test of Auditory Processing Skills – 3 (TAPS-3)* (Martin & Brownell, 2005). For the digit span task, participants are provided verbally with digit strings of increasing length, and are required to repeat each string immediately after the examiner's presentation. Similarly, for the word span task, participants are provided verbally with word strings of increasing length, and are required to repeat each string immediately after the examiner's presentation. During the sentence repetition task, participants are provided verbally with sentences of increasing length and complexity, and are required to repeat each sentence immediately after the examiner's presentation.

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

Naming and Comprehension Stimuli

Thirty-six verb and 36 noun target lists, matched for cumulative frequency and number of syllables, were used for the naming task (Francis & Kučera, 1982; Kim & Thompson, 2000, 2004). Single word targets were the same as those used by Kim & Thompson (2000, 2004). Nouns, verbs, and frequency data used for naming and comprehension tasks are listed in Appendix A. Frequency values for nouns and verbs are taken from the *Standard Corpus of Present-Day American English*, which contains approximately 1,014,000 words of text taken from informative and imaginative prose. The frequency number represents the number of times a word appears in the corpus (Francis & Kučera, 1982). A number of words can be used as both nouns and verbs. For each verb, the proportion of nominal use is provided, and vice versa (Francis & Kučera, 1982). Two verbs (*bark, cry*) and one noun (*arm*) were included, although their percent usage for the other form class slightly exceeded 25%, because the meaning of the word is different when used as a noun and as a verb.

The verbs were classified as one-place, two-place, or three-place, 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 agrammatic aphasic individuals' naming and categorization patterns (Kim & Thompson, 2000).

Frequency and phonological properties of words can potentially affect the accuracy and efficiency of word retrieval. A nonparametric two-sample test (Mann-Whitney, corrected for tied ranks and converted to yield a Z score) was used to compare the noun and verb word sets and analyses of variance (Tukey-Kramer

multiple comparisons) were conducted to compare the verb type word sets in order to investigate whether these factors were likely to contribute to any significant differences. Alpha was set at .05 (two-tailed) for each comparison. No significant differences were found between the noun and verb word sets or the verb type word sets for frequency (Carroll, Davies, & Richman, 1971; Francis & Kučera, 1982), phonological neighborhood density (i.e., the number of words that differ from the target word by one phoneme), or the frequency with which the general sound pattern of the target word is encountered (i.e., phonotactic probability) (Vitevitch & Luce, 2004). Details of these comparisons are recorded in Appendix B.

Black and white line drawings served as stimuli for the noun and verb targets. All pictures were hand-drawn. All stimulus-item drawings used in the comprehension and naming tasks were piloted in a naming task with 10 typically-functioning adults. All drawings elicited target responses in at least 90% of piloted responses. Examples of noun and verb stimulus items appear in Appendix C.

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.

Receptive Tasks

Single Word Comprehension

During each trial of the comprehension task, participants saw four drawings at a time. One drawing labeled the target word while three distractor drawings represented a meaningfully-related (semantic), a phonologically-related

(phonological), and an unrelated word. The position of the target word was counterbalanced for each trial of the task and the position of the distractor words was randomized for each trial of the task. Position of target words and distractor words for each trial was the same for all participants. A complete listing of the target and distractor words used in the comprehension task is recorded in Appendix D. Trial order was randomized for each participant. Participants were instructed to point to the drawing representing the noun or verb presented by the experimenter. Noun and verb comprehension trials were administered separately. Participants were instructed before the noun and verb portions of the task whether the following pictures would illustrate things or actions. Five individuals with DS and five individuals from the control group received the noun portion of the task first, and four individuals with DS and four individuals from the control group received the verb portion of the task first. 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. Accuracy of picture identification was recorded for nouns, verbs, and verbs by verb type (one-place, two-place, and three-place), and percentage accuracy for nouns, verbs, and each verb type was calculated for each participant.

Grammaticality Judgments

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). All sentences used in the task were in the present tense and followed subject-verb-object word

order. 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*). Half of the sentences were grammatical and half were 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 for sentence length (i.e., number of words) (mean grammatical: 7.5; mean ungrammatical: 6.5; Mann-Whitney $Z = 1.1979$, n.s.). A complete listing of the sentence stimuli used in the grammaticality judgment task appears in Appendix E. The sentences were presented in random order for each participant.

The examiner presented all sentences verbally while the sentence was viewed in print on the laptop. Participants were given instructions before the task that read: “You are going to listen to some sentences. I want you to tell me if each sentence sounds (good/OK/grammatical) or (bad/silly/ungrammatical).” All adjectives in the instructions were presented to each participant. Participants were also instructed that they were not to respond to the content of the sentence, but rather the grammaticality of the sentence. Participants were instructed to point to one of two pictures after listening to each sentence, one that represents “good grammar” (a happy face) and one that represents “bad grammar” (a frowning face). Participants were provided with a four-item practice set- 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) . Participants were given 20 seconds to respond. Accuracy of responses was recorded, and percentage of accurate responses was calculated for each participant.

Expressive Tasks

Single Word Naming

During each trial of the naming task, participants were presented with a black and white line drawing on a Macintosh laptop. Responses were recorded using a portable digital voice recorder. Nouns and verb naming trials were administered separately. Participants were instructed before the noun naming and verb naming portions of the task whether the following pictures would illustrate things or actions, and were provided with two practice items before each portion of the task.

Participants were given a two-item practice set at the beginning of both the noun and verb naming portions of the task. Five individuals with DS and five individuals from the control group received the noun portion of the task first, and four individuals with DS and four individuals from the control group received the verb portion of the task first. Participants were given 20 seconds to respond for each trial of the naming task. Semantically-appropriate responses (e.g., *cup* for *glass*, and *hand* for *give*) were considered accurate responses. All semantically appropriate verb responses were determined to have the same argument structure as the target verbs (e.g., *mix* for *stir*, *jog* for *run*).

Response times for all participants were calculated for each trial that elicited a target response. A beep coincided with the presentation of each picture. An audio program, Audacity, was used to calculate the time from the beginning of the beep to the first sound of a target response. Accuracy of naming was recorded, and proportional accuracy of nouns, verbs, and each verb type (one-place, two-place, three-place) was calculated for each participant.

Narratives

Participants were asked to narrate simple stories (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. Story prompts are provided in Appendix F. Participants were presented with the pictures, one at a time, and were asked to follow along as the examiner narrated the story. The examiner paused at each picture as she narrated the story, providing a sentence for each picture. The participants were then provided with the same picture 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 participants' retelling of each story. A total of 10 stories, including one practice story at the beginning, were presented to each participant in a random order (excluding the practice story which always occurred at the beginning). Three of the 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 in the one-place stories was 23.6, and the two-place and three-place stories

both averaged at 24 words. The mean number of words in one-place target sentences was 5.9, the mean number of words in two-place target sentences was 6.2, and the mean number of words in three-place target sentences was 6.7. The responses to the entire task were recorded.

Narratives were transcribed to identify the percentage of target utterances including verbs, as well as the proportion of target sentences of each verb type (one-, two-, and three-place) for each participant. The proportions of target verbs produced for all target utterances and target utterances of each verb type were also calculated. In addition, the percentage of one-place, two-place, and three-place target verbs produced with correct argument structure as well as the overall proportion of target verbs produced with correct argument structure were computed. Elements of argument structure were considered present and accurate if any word representing the element of argument structure in question was present. For example, the utterance “*Mary give cookie her*” was considered accurate because the 3 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 following optional three-place verbs were considered to have accurate use of argument structure if a subject element was present: *bake*, *cut*, *knit*, *read*, *sew*, and *write*. The optional three-place verb *fry* was considered to have accurate use of argument structure if a subject and direct object was present. Unintelligible sentences were excluded from analysis. Four target sentences (two two-place sentences and

two three-place sentences) were lost due to unintelligibility, one each produced by four different participants with DS.

Analyses

In preliminary analyses, assumptions of homogeneity of variances were not met for most comparisons. Therefore, to maintain consistency, all two-sample tests were performed using a nonparametric test (Mann-Whitney, corrected for tied ranks and converted to yield a Z score). Spearman's rank correlations were used for all measures of correlation and reliability. Tukey-Kramer multiple comparison tests were used for all analyses of variance. Alpha was set at .05 (two-tailed) for each comparison. Comparisons were computed using NCSS 2007 (Hintze, 2006). Proportion accuracies 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. Effect sizes were calculated by using Cohen's d to find an effect-size r . Effect sizes were interpreted using guidelines outlined by Cohen (1988)- small effect size, $r = .20 - .50$; moderate effect size, $r = .51 - .80$; large effect size, $r = 0.81$ or greater.

Results

Memory Tasks

Tasks Requiring Nonverbal Responses

It was hypothesized that the individuals with DS and the control group would perform similarly on memory tests requiring a nonverbal response. Consistent with this hypothesis, no statistically significant differences were found between the DS and TD groups for digit span (DS $M = 2.9$, $SD = 1.7$; TD $M = 4.6$, $SD = 2.2$; Mann-Whitney $Z = 1.4875$, n.s.), word span (DS $M = 3.1$, $SD = 1.3$; TD $M = 3.5$, $SD = 2.3$; Mann-Whitney $Z = .1776$, n.s.), or spatial memory (DS $M = 3.9$, $SD = 1.3$; TD $M = 4.3$, $SD = 2.1$; Mann-Whitney $Z = .1777$, n.s.). The DS and TD groups did not differ significantly on any memory tasks requiring a nonverbal response.

Tasks Requiring Verbal Responses

It was predicted that the individuals with DS would perform more poorly on memory tasks requiring a verbal response than the TD control group. This trend was observed, although analyses revealed no significant differences between the DS and TD groups on either the digit span task (DS $M = 9.9$, $SD = 4.5$; TD $M = 12.3$, $SD = 4.5$; Mann-Whitney $Z = 1.2965$, n.s.) or the word span task (DS $M = 10.7$, $SD = 4.5$; TD $M = 13$, $SD = 4.9$; Mann-Whitney $Z = .9931$, n.s.) requiring a verbal response. However, a significant difference was found between the DS and TD groups 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 2). Effect-size correlation indicated a moderate

effect size ($r = .69$). 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.

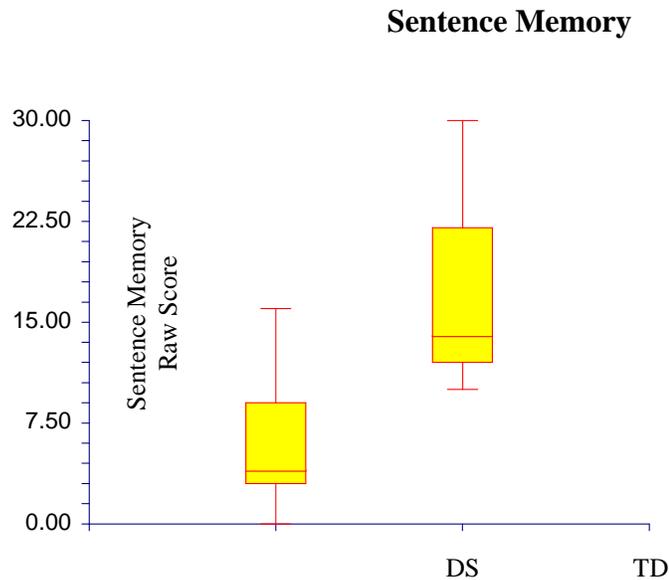


Figure 2. Sentence memory raw scores (mean, spread, and interquartile range)

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. Consistent with this hypothesis, no significant differences were found between the DS group and the TD group on noun comprehension accuracy (DS $M = .97$, $SD = .002$; TD $M = .97$, $SD = .004$; Mann-Whitney $Z = .7516$, n.s.) or verb comprehension accuracy (DS $M = .88$,

$SD = .008$; TD $M = .92$, $SD = .009$; Mann-Whitney $Z = 1.2033$, n.s.). The DS group and the TD group performed similarly on both the noun and verb comprehension tasks.

Single-Word Naming

A suspected deficit in verb retrieval in DS led to the hypothesis 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 $M = .86$, $SD = .007$; TD $M = .85$, $SD = .105$; Mann-Whitney $Z = .0890$, n.s.) or the verb-naming task (DS $M = .51$, $SD = .237$; TD $M = .64$, $SD = .197$; Mann-Whitney $Z = 1.2369$, n.s.). In addition, the groups were compared for proportions of target noun and verb responses (not including other semantically-appropriate, accurate responses). No significant difference was found between the DS and TD groups for proportions of target responses on the noun-naming task (DS $M = .78$, $SD = .11$; TD $M = .79$, $SD = .11$; Mann-Whitney $Z = .2233$, n.s.) or the verb-naming task (DS $M = .45$, $SD = .24$; TD $M = .56$, $SD = .22$, Mann-Whitney $Z = .9825$, n.s.). The DS group and the TD group did not differ significantly on naming accuracy on the noun or verb naming tasks.

Some items proved to be especially problematic in eliciting accurate participants across participants. That is, some pictures were often visually confused (e.g., *leg* for target response *arm*; *cry* for *laugh*) or elicited a response focusing on an unintended aspect of the picture (e.g., *sleep* for *snore*). In order to ensure that such items (those that were mis-named more than one third of the time) did not influence

the results, these items were removed from the word sets in pairs, in such a way as to maintain the matching across noun and verb lists, and *post-hoc* analyses were conducted with these words excluded. The general patterns of results remained identical; therefore data from the full word sets are reported.

It was hypothesized that individuals with DS would take longer to retrieve verbs than the TD individuals. To ensure that comparisons could be made across subjects, reaction times were only analyzed when target responses were elicited from both the DS individual and their TD match. Contrary to expected results, no significant difference was found between the DS group and the TD group in verb naming reaction time (DS $M = 1971$, $SD = 1052$; TD $M = 1558$, $SD = 273$; Mann-Whitney $Z = .1766$, n.s.) and a significant difference was found between the DS and TD groups in noun naming reaction time (mean DS $M = 1285$, $SD = 373$; TD $M = 1971$, $SD = 1052$; Mann-Whitney $Z = 2.2959$, $p = .022$), with the individuals with DS retrieving nouns significantly faster than TD individuals. However, these results should be interpreted cautiously. Accurate target responses (in contrast with accurate responses, which include semantically-appropriate non-target responses) were elicited rarely from some participants, especially target verbs. Thus, RT analyses could only be completed for a small portion of the data set (32% of verb-naming responses, and 64% of noun-naming responses) and are not felt to be representative of typical word retrieval latencies.

Narratives

It was hypothesized that the DS group would produce fewer verbs in their narratives compared to the TD group, indicating a specific deficit in verb retrieval.

Consistent with this hypothesis, there was a significant difference between the DS group and the TD group on percentage of target sentences containing verbs (DS $M = .83$, $SD = .18$; TD $M = .99$, $SD = .02$; Mann-Whitney $Z = 2.1866$, $p = .029$). Effect-size correlation reflected a moderate effect size ($r = .52$). The DS group omitted verbs from target sentences in their narratives significantly more often than the TD group.

Grammaticality Judgment Task

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 $M = .55$, $SD = .16$, TD $M = .74$, $SD = .20$; Mann-Whitney $Z = 2.0373$, $p = .042$). Effect-size correlation reflected a small effect size ($r = .46$). 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.

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 trend for both groups to have more difficulty retrieving verbs as the number of arguments increased (See Figure 3). Furthermore, the trend in the DS group appears to reflect a more consistent

change across verb type (more difficulty with verb retrieval as the number of arguments increases) than the TD group, although this change only represents an approximate one-item difference in performance between one-place and three-place verbs. To investigate differences in verb-naming accuracy by verb type within the DS group, a Tukey-Kramer multiple comparison test was used. No significant differences were found between verb-naming accuracy for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

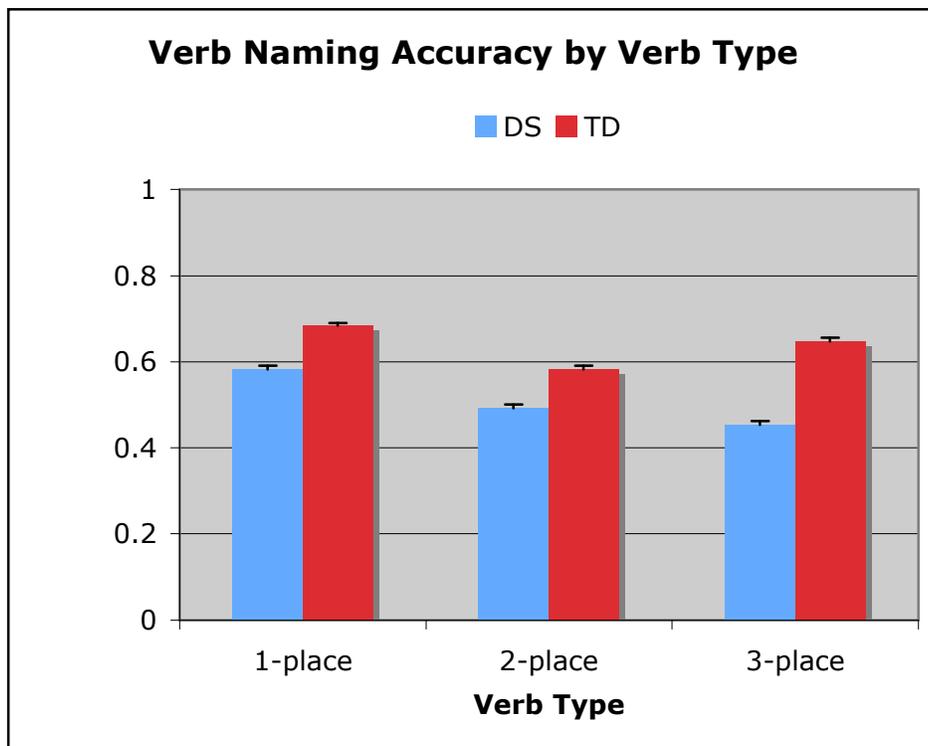


Figure 3. Verb naming proportion accuracy by verb type + standard error (SE)

Narratives

It was hypothesized that the DS group would omit verbs in target sentences in their narratives more often as the number of arguments associated with a verb increased, and that they would be more affected by verb argument demands than the TD group. No significant difference between the DS group and TD group was found in production of verbs in one-place target sentences (DS $M = .86$, $SD = .16$; TD $M = .98$, $SD = .005$; Mann-Whitney $Z = 1.6178$, n.s.). However, significant differences between the DS group and TD group were found for production of verbs in two-place target sentences (DS $M = .85$, $SD = .16$; TD $M = 1$, $SD = 0$; Mann-Whitney $Z = 2.7892$, $p = .005$) and three-place target sentences (DS $M = .80$, $SD = .28$; TD $M = 1$, $SD = 0$; Mann-Whitney $Z = 2.1259$, $p = .034$) (See Figure 4). Effect-size correlation indicated moderate and small effect sizes (two-place $r = .55$.; three-place $r = .45$). The DS group omitted two-place and three-place verbs significantly more often than the TD group, who performed basically at ceiling and rarely omitted verbs.

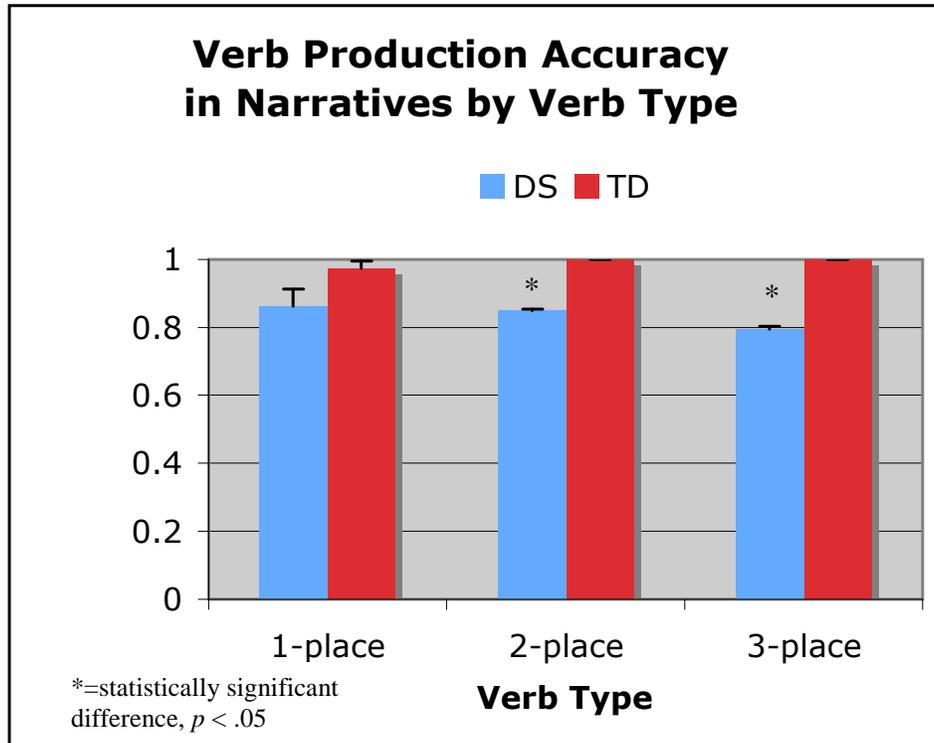


Figure 4. Verb production accuracy in narratives by verb type + SE

To explore differences in verb production accuracy by verb type within the DS group, a Tukey-Kramer multiple comparison test was used. No significant differences were found between verb production accuracy in narratives for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

It was predicted that the DS group would omit necessary elements of argument structure more often than the TD group. Consistent with this hypothesis, there was a significant difference between the DS group and TD group on accurate argument structure production with target verbs (DS $M = .71$, $SD = .33$; TD $M = .99$, $SD = .003$; Mann-Whitney $Z = 2.8113$, $p = .005$). Effect-size correlation reflected a moderate effect size ($r = .51$). That is, when target verbs were analyzed for

production of argument structure, individuals with DS produced significantly fewer elements of obligatory argument structure than TD individuals.

It was also hypothesized that omission of obligatory elements of argument structure would increase for the DS group as the number of arguments associated with the verb increased. Analyses revealed no significant difference between the DS and TD groups for accuracy of argument structure for target one-place verbs (DS $M = .85$, $SD = .33$; TD $M = 1$, $SD = 0$; Mann-Whitney $Z = 1.7669$, n.s.). However, accuracy of argument structure production was significantly different between the DS and TD groups for target two-place (DS $M = .57$, $SD = .46$; TD $M = .98$, $SD = .002$; Mann-Whitney $Z = 2.1051$, $p = .035$) and three-place verbs (DS $M = .71$, $SD = .32$; TD $M = .98$, $SD = .006$; Mann-Whitney $Z = 2.5126$, $p = .012$) (See Figure 5). Effect-size correlation reflected moderate effect sizes (two-place $r = .53$; three-place $r = .51$). 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.

To investigate differences in argument structure accuracy by verb type within the DS group, a Tukey-Kramer multiple comparison test was used. No significant differences were found between argument structure accuracy in narratives for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

The inclusion of optional two-place and three-place verbs in the narrative task often allowed participants to use these verbs accurately with only a subject argument. All optional two-place and three-place verbs were considered to have correct argument structure if a subject argument was present, except for the three-place verb

fry, which was considered to have correct argument structure if subject and direct object arguments were present. A second judge, blind to participant group as well as verb type classifications, scored the accuracy of argument structure in each target sentence. Inter-rater reliability was greater than 90% for argument structure accuracy for all target sentences as well as by verb type.

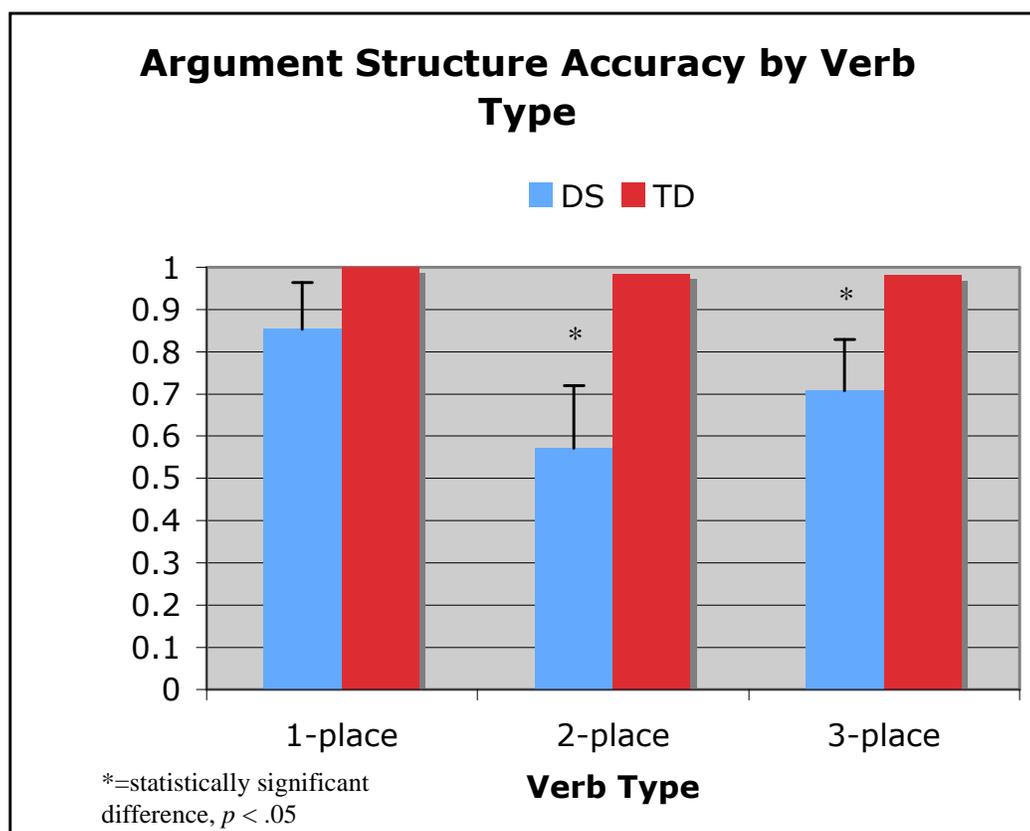


Figure 5. Argument structure proportion accuracy in narratives by verb type + SE

It can and should be argued that omission of necessary elements of argument structure will increase as the number of arguments associated with a verb increases simply because there are more arguments (i.e., opportunities) to omit necessary

elements. This effect is somewhat minimized by the inclusion of optional two- and three-place verbs in the narrative task, most of which only require a subject. To further investigate whether the pattern of inaccurate argument structure as a function of verb type is present despite the notion that there are more opportunities to omit arguments in sentences containing two-place and three-place verbs, 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 $M = .74$, $SD = .34$; 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 correlation indicated a small effect size ($r = .48$). There was no significant difference between the DS and TD groups on percentage of target one-place verbs with subject arguments (DS $M = .85$, $SD = .33$; TD $M = 1$, $SD = 0$, Mann-Whitney $Z = 1.7669$, n.s.). However, the DS and TD groups were significantly different on percentage of two-place verbs with subject arguments (DS $M = .62$, $SD = .44$; TD $M = 1$, $SD = 0$; Mann-Whitney $Z = 2.4606$, $p = .014$) and three-place verbs with subject arguments (DS $M = .76$, $SD = .33$; TD $M = 1$, $SD = 0$; Mann-Whitney $Z = 2.4585$, $p = .014$) (See Figure 6). Effect-size correlation reflected moderate and small effect sizes (two-place $r = .52$; three-place $r = .46$).

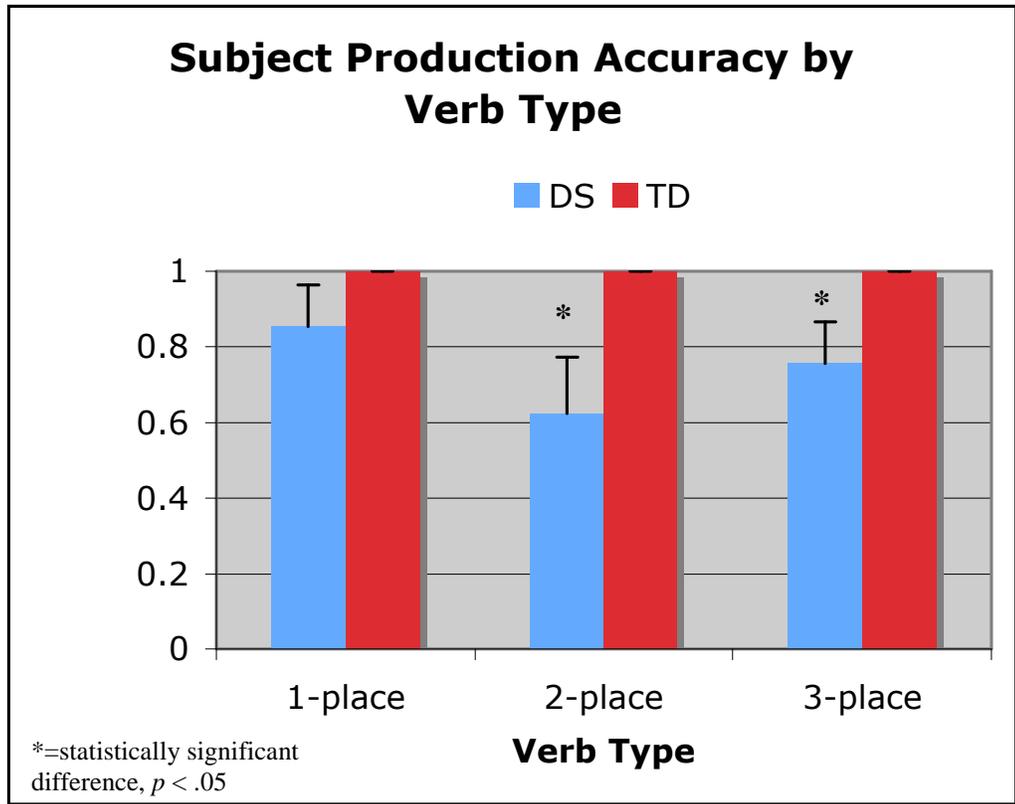


Figure 6. Subject production proportion accuracy in narratives by verb type + SE

To investigate differences in subject production accuracy by verb type within the DS group, a Tukey-Kramer multiple comparison test was used. No significant differences were found between subject production accuracy in narratives for one-place, two-place, and three-place verbs within the DS group ($p > .05$).

Predictors

The participants with DS represented a wide range of ages (11;11-32;10). To explore whether performance varied as a function of age within the DS group, correlations between age and performance on several tasks were calculated. No

significant correlations were found between age and grammaticality judgment accuracy, verb-naming accuracy, or subject production accuracy in the DS group ($p > .05$). To explore whether sentence memory had an effect on narrative performances (in both groups), correlations between sentence memory and measures of narrative performance (verb production accuracy, argument structure accuracy, and subject production accuracy) were calculated. 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 ($r = .74, p = .0005$).

Discussion

This study investigated the ability to retrieve and comprehend verbs and elements of argument structure in individuals with DS compared to typically-developing children of comparable language-age. No memory deficits were found in individuals with DS (when compared to language age matches) when the task required retaining and retrieving strings of isolated words or numbers, presented verbally or visually, whether they required a verbal or nonverbal response. Relatively successful retrieval of visual information, namely the spatial memory task requiring a nonverbal response, was consistent with previous findings indicating that DS individuals are not impaired relative to learning-disabled, non-DS individuals on tasks that rely on storage, retention, and retrieval of visual information (Bower & Hayes, 1994; Chapman, 2006; Rowe et al., 2006). However, contrary to previous findings (Bower & Hayes, 1994; Chapman, 2006; Rowe et al., 2006), DS individuals

also performed similarly to language-age matched TD individuals when asked to repeat digits and words. 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 to TD individuals of comparable language age, but that grammatical processing affects the ability for DS individuals 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 via the speaker's internal grammatical rules. This finding reinforces the theory of a specific deficit in expressive grammar (syntax) in individuals with DS (Chapman & Hesketh, 2000; Chapman et al., 1998; Vicari et al., 2000) that serves as a basis for this study.

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 TD individuals 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 TD individuals 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 group may explain the similarity in performance on this task. Although the DS group may have a specific difficulty retrieving verbs, the TD group may not have been exposed to as many verbs as the DS group as often as the DS group, 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 DS group to perform worse than the TD group 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 TD individuals 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 TD individuals on this task, and in fact performed at near chance level. Observation suggests that individuals with DS often appeared to guess on this task, and also often misinterpreted task instructions. 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 TD individuals 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 more significantly more likely to omit verbs in target sentences than TD individuals. 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 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) 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 to 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 (except for the optional three-place verb, *fry*). Effects of verb type on verb and argument structure retrieval in individuals with DS compared to TD individuals, despite of 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 TD individuals in subject argument production. Individuals with DS were more significantly likely to omit subjects in sentences with two-place and three-place verbs than TD individuals, 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 requiring 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. The two-place and three-place narratives in this study all followed the activities of one character, and therefore the listener could easily recover the subject.

This study found that individuals with DS have a specific deficit in verb retrieval compared with TD individuals matched for language age, which was most apparent in omission of verbs in narrative productions. 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 (namely 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 TD individuals, 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 TD individuals 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 to 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), increasing the likelihood that verb type contributed to significant differences in performance, rather than sentence length alone. Although the participants with DS represented a wide variety of ages and skill levels, no correlations were found between age and

performance on grammaticality judgment, verb-naming accuracy, or subject production accuracy in the DS group. While it is expected that language skill measures will generally improve with age in typically-developing individuals, this was not found between subjects in the DS group. Therefore, age is not considered a major contributing factor in the significant differences found between the DS and TD groups.

Limitations of the current study

Despite confirmation of many of the hypotheses that were made regarding the profiles of verb use in individuals with DS, there are a number of potential limitations of this study, including the relatively small sample size and the experimenter's awareness of group membership of each participant during experimentation and analysis (lack of blinding).

With regard to the first issue, despite small sample sizes, significant results supporting the overall hypotheses were still found using conservative statistical analyses and criteria for determination of statistical significance. Replicating these results with a larger sample of individuals with DS and language age matches could strengthen these findings.

Down Syndrome is a very evident physical condition, and the speech of individuals with DS has characteristics that do distinguish it from the speech of unaffected speakers. Thus, awareness of group membership by the experimenter was unavoidable, but should not have unduly influenced the results of this study. Definitions of accuracy for most tasks were objective, indicating reliable outcome measures. However, calculation of reaction times and judgments of verb and noun

naming accuracy (i.e., semantically-appropriate responses) were not strictly objective measures and therefore were subject to interpretation.

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 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. In the child language acquisition literature, theorists and researchers have posited that subject expression is a basic linguistic concept that distinguishes between broad groups of the world's languages (so-called "pro-drop" languages, such as Spanish) that permit subject dropping and those that do not. Further, there has been speculation that a basic default setting in learning language is to presume that a language permits pro-drop unless otherwise specified (Hyams, 1986). Partial support for this hypothesis is that very young English language-learners also omit subjects when their expressive language capacity

appears to be stressed. For example, young English-speaking children produce sentences such as “*Want more cookies,*” and gradually learn that the subject is obligatory. It is argued that young English language-learners initially treat English as though it were a pro-drop language (Hyams, 1986). Further exploration of this phenomenon in speakers with DS, particularly at younger ages, may provide interesting data for theories regarding either natural, less “marked” syntactic structures in the speech of language learners, or how individuals cope with language production demands in the face of capacity limitations. 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.

The question remains whether an impairment in verb and argument structure retrieval in individuals with DS reflects a poorly organized lexicon, incomplete entries in the lexicon, and/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 area of DS and language, particularly on adults, especially 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 disparity between cognitive skills and

language skills implies that language abilities may increase despite a relatively stable cognitive impairment. This discrepancy supports the view that individuals with DS are able to continue to master language skills well into their adult years. Increased understanding of how language develops in individuals with DS will give way to more effective methods of improving language and communication skills in this population

Appendices

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
Mean (SD)	165.4 (264.5)			147.7 (181.1)	

This word list is taken from Kim & Thompson (2000, 2004).

Appendix B

Word Set Analyses

Frequency

Two measures of word log frequency were used in the word set comparisons—the Francis & Kučera (1982) frequency measure and a frequency measure (U-statistic) from the Carroll, Davies, & Richman (1971) corpus. The latter was included because this corpus drew its sample from materials likely to be encountered by school-age children.

Phonological Neighborhood Density

In order to determine neighborhood density, each target word was looked up phonologically in a computerized version of Webster's dictionary. All words in the lexicon that differed from the target word by a single phoneme (either a single phoneme addition, deletion, or substitution) and that had familiarities of at least 6.0 on the 7-point familiarity scale (Nusbaum, Pisoni, & Clark, 1984) were considered to be neighbors for this analysis. Both number of neighbors and frequency-weighted neighborhood density were compared between word sets.

Phonotactic Probability

Both phoneme-based phonotactic probability and biphone-based phonotactic probability were used in word set comparisons. Phonotactic probability refers to the frequency that a phonological segment or sequences of phonological segments (e.g., biphones) occur in a specified position in a word. A web-based Phonotactic Probability Calculator (PPC) (Vitevitch & Luce, 2004) was used to estimate phonotactic probability measures.

Noun and Verb Word Set Comparisons

A nonparametric test (Mann-Whitney, corrected for tied ranks and converted to yield a Z score) was used to compare the noun and verb word sets. Alpha was set at .05 (two-tailed) for each comparison. The noun and verb word sets were not significantly different for word frequency (Francis & Kučera (1982): Mann-Whitney $Z = 0.1183$, n.s.; Carroll, Davies, & Richman (1971): Mann-Whitney $Z = 0.2647$, n.s.), number of phonological neighbors (Mann-Whitney $Z = 0.0056$, n.s.), frequency-weighted neighborhood density (Mann-Whitney $Z = 0.5350$, n.s.), phoneme-based phonotactic probability (Mann-Whitney $Z = 0.1577$, n.s.), or biphone-based phonotactic probability (Mann-Whitney $Z = 0.4256$, n.s.).

Verb Type Word Set Comparisons

The target verbs were compared across verb type using Tukey-Kramer multiple comparison tests. Alpha was set at .05 (two-tailed) for each comparison. The verb type word sets were not significantly different for word frequency, number of phonological neighbors, frequency-weighted neighborhood density, phoneme-based phonotactic probability, or biphone-based phonotactic probability.

Appendix C

Noun and Verb Stimulus Examples

grapes

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

zip

A TIFF image
cannot be displayed.
The image may be
corrupted or the
TIFF decompressor
may not be installed.

Appendix D

Distractor Words: Verbs

TARGET VERB	PHONOLOGICAL DISTRACTOR	SEMANTIC DISTRACTOR	UNRELATED DISTRACTOR
bark	bake	meow	kneel
crawl	fall	kneel	snore
cry	fry	laugh	weigh
jump	dump	fall	measure
laugh	clap	cry	climb
pray	rake	church	clap
run	gun	jump	meow
sit	swim	kneel	bury
sneeze	sweep	wink	ride
snore	pour	laugh	weigh
swim	sit	walk	throw
wink	think	wave	build
carry	bury	give	listen
erase	rake	write	crawl
pull	spill	carry	erase
spill	swim	pour	bark
stir	spill	chop	mop
weigh	shave	measure	mop
zip	trip	tie	glue
climb	cry	slide	tie
ride	slide	run	think
shave	wave	brush	carry
sweep	sneeze	mop	wave
watch	walk	listen	knit
give	zip	put	chop
put	pull	give	pray
bake	rake	fry	listen
build	bite	sew	trip
cut	put	glue	dump
fry	tie	bake	clap
knit	sit	sew	dump
pour	pull	stir	watch
read	ride	write	glue
sew	row	knit	bite
throw	row	run	cut
write	bite	read	brush

Distractor Words: Nouns

TARGET NOUN	PHONOLOGICAL DISTRACTOR	SEMANTIC DISTRACTOR	UNRELATED DISTRACTOR
kite	cat	sun	stapler
belt	bat	tie	pie
hat	bat	belt	star
moon	shoe	sun	pencil
box	book	tape	shoe
shirt	shark	pants	axe
church	shirt	house	belt
door	deer	house	nest
pear	chair	grapes	gun
vest	nest	pants	box
shoe	shell	socks	corn
axe	tacks	knife	stool
foot	book	hand	bell
carrot	parrot	grapes	tacks
gun	sun	knife	seal
stool	seal	table	rabbit
corn	car	pear	vest
boot	bat	socks	glass
goat	gate	dog	horn
nose	nest	eye	church
window	windmill	door	boot
bell	shell	horn	tree
star	car	moon	hat
arm	heart	nose	bus
hand	pants	foot	window
house	mouse	window	parrot
rabbit	parrot	goat	tree
table	stapler	chair	shark
heart	arm	moon	bus
glass	tacks	table	kite
grapes	tape	pear	dog
bus	bun	car	gate
book	foot	pencil	rabbit
pie	kite	carrot	deer
tree	deer	flower	hat
eye	pie	nose	box

Appendix E

Grammaticality Judgment Sentences

A. Grammatical sentences with basic argument structure

Obligatory One-Place (Ob1)

1. The dog is barking.
2. The girl is sitting.
3. The man is snoring.
4. The boy is swimming.

Obligatory Two-Place (Ob2)

5. The boy is carrying the box.
6. The girl is erasing the chalkboard.
7. The boy is spilling the milk.
8. The woman is weighing the package.

Obligatory Three-Place (Ob3)

9. The woman is giving the money to the girl.
10. The boy is leaning the ladder against the wall.
11. The man is putting the book on the table.

B. Grammatical sentences with an additional adjunct

Obligatory One-Place (Ob1)

1. The baby is crawling in the house. (+locative)
2. The lady is praying in her room. (+locative)
3. The man is crying at night. (+temporal)
4. The boy is running toward the girl. (+goal/+locative)

Obligatory Two-Place (Ob2)

5. The man is carrying the box to the car. (+locative)
6. The girl is spilling the milk in the kitchen. (+locative)
7. The man is erasing the name from the book. (+locative)
8. The boy is pulling the cart in the yard. (+locative)

Obligatory Three-Place (Ob3)

9. The woman is giving the money to the girl in the car. (+locative)

10. The boy is leaning the ladder against the tree in the garden. (+locative)
11. The man is putting the book on the table in the bedroom. (+locative)

C. Ungrammatical sentences with omission of argument(s)

- a. Without an additional adjunct

Obligatory Two-Place (Ob2)

1. The boy is carrying. (-NP)
2. The boy is pulling. (-NP)

Obligatory Three-Place (Ob3)

3. The woman is giving to the driver (-NP)
4. The man is putting. (-NP)(-PP)
5. The man is putting the dollar. (-PP)
6. The man is putting on the table. (-NP)
7. The boy is sticking on the envelope. (-NP)

- b. With an additional adjunct

Obligatory Two-Place (Ob2)

8. The boy is carrying in the park (-NP) (+locative)
9. The boy is pulling to the house. (-NP) (+locative)

Obligatory Three-Place (Ob3)

10. The boy is sticking in the morning. (-NP)(-PP)(+temporal)
11. The man is putting in the afternoon. (-NP)(-PP)(+temporal)
12. The man is putting the book at night. (-PP)(+temporal)

D. Ungrammatical sentences with addition of an illegal argument

Obligatory One-Place (Ob1)

1. The boy is sneezing the girl.
2. The man is laughing the woman.
3. The boy is jumping the bed.
4. The girl is sitting the chair.
5. The boy is winking the girl.

Obligatory Two-Place (Ob2)

6. The man is carrying the boy a box.
7. The boy is erasing her the chalkboard.
8. The girl is stirring the man the soup.
9. The boy is pulling the girl the cart.
10. The girl is zipping the boy the jacket.

NP: Noun Phrase

PP: Prepositional Phrase

Adapted from Kim & Thompson (2004)

Appendix F

Narratives

1. Babies (1-place)
 - a. Babies are small and cute.
 - b. Babies *sit* in highchairs.**
 - c. Babies *crawl* on the floor.**
 - d. Babies *cry* when they are hungry.**

2. The Pool (1-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.**

3. Nighttime (1-place)
 - a. It is nighttime at the Jones house.
 - b. Mr. Jones *sleeps* in his bed.**
 - c. He *snores* loudly in his sleep.**
 - d. Mrs. Jones *laughs* at the funny noises.**

4. Cake (2-place)
 - a. Sally *weighs* one pound of flour in the kitchen.**
 - b. Sally *stirs* the cake batter until it's ready.**
 - c. Sally *spills* some cake batter on the floor.**
 - d. The cake is finished.

5. Getting Ready (2-place)
 - a. Mr. Jones is getting ready for work.
 - b. He *shaves* his beard in the bathroom.**
 - c. He *zips* his jacket.**
 - d. Mr. Jones *rides* his bike to work.**

6. Joey (2-place)
 - a. Joey is helping the teacher.
 - b. He *carries* the teacher's books.**
 - c. He *erases* the chalkboard.**
 - d. He *sweeps* the floor.**

7. Teacher (3-place)
 - a. Miss Green is a teacher.
 - b. She *reads* a book to the class.**
 - c. She *writes* the alphabet on the chalkboard.**
 - d. She *puts* a star on a paper.**

8. Hungry
 - 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.**

9. Making Clothes
 - a. Betty is making clothes.
 - b. She *cuts* fabric with scissors.**
 - c. She *sews* a patch on her pants.**
 - d. Betty *knits* a scarf for her friend.**

Target sentences are bolded.

Target verbs are italicized.

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