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SENTENCE COMPLEXITY IN CHILDREN WITH AUTISM AND SPECIFIC LANGUAGE IMPAIRMENT

by

Sarah Ann McConnell

A thesis submitted in partial fulfillment of the requirements for the
Master of Arts degree in Speech Pathology and Audiology
in the Graduate College of
The University of Iowa

May 2010

Thesis Supervisor: Professor Karla K. McGregor

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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has been approved by the Examining Committee for the thesis requirement for the Master of Arts degree in Speech Pathology and Audiology at the May 2010 graduation.

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ACKNOWLEDGEMENTS

The author would like to acknowledge Dr. Karla McGregor, Stephanie Cain, Nichole Eden, Gwyneth Rost, and all of the members of the Word Learning Lab; Whitney Achenbaugh, Dr. Amanda Owen, and all of the members of the Grammar Acquisition Lab; and Dr. J. Bruce Tomblin. This project was funded in part by: NIH 5RO1DC003698-08.

ABSTRACT

Children with high-functioning autism, children with specific language impairment, children with autism and language impairment, and controls produced sentences after a prompt to form a sentence using a specific word. The sentences were analyzed for length and syntactic complexity.

Children with language impairment, regardless of autism diagnosis, made less complex sentences than their age peers. However, children with autism and language impairment exhibited a broader range of ability than children with language impairment alone. Children with high-functioning autism without concomitant structural language impairment created sentences of similar complexity to age peers. Word variables also influenced sentence complexity, with word meaning (abstract vs. concrete) having the most robust effect and word frequency having a negligible effect.

Implications for this study in relation to double-deficit and syntactic bootstrapping models are discussed.

TABLE OF CONTENTS

LIST OF TABLES v

LIST OF FIGURES vi

BACKGROUND 1

Current Study 4

METHODS 9

Subjects 9
Stimuli 11
Data Collection 12
Coding 13
Omitted Sentences 15
Data Analysis 15

RESULTS 17

Acceptable Sentences Produced 17
Omitted Sentences 18
Mean Length of Utterance 18
Clauses per Sentence 19
Points per Sentence 21

CONSLUSIONS 26

Limitations of the Study 28

DISCUSSION 31

Group Variables 31
Word Variables 33
Group and Word Variables 35

IMPLICATIONS 36

APPENDIX A. SUBJECT DEMOGRAPHIC DATA 37

APPENDIX B. LIST OF STIMULI 39

APPENDIX C. TASK INSTRUCTIONS 40

APPENDIX D. COMPLEX SYNTAX CODING KEY 41

REFERENCES 44

LIST OF TABLES

Table 1.	Example one syntactic codes, description, and point value for each	16
Table 2.	Example two syntactic codes, description, and point value for each	16
Table 3.	Within-group comparisons of clause density by word class	22
Table 4.	Comparisons of clause density by word class, frequency, and meaning	22
Table A1.	Demographic and test data expressed as group means (and standard deviations)	37
Table A2.	*p* values for all t-test comparisons of demographic and test data	38
Table B1.	Full stimuli list sorted by word class, frequency, and meaning	39
Table D1.	Complex syntax coding key, sentence complexity index	41

LIST OF FIGURES

Figure 1.	Acceptable sentences by diagnostic group	22
Figure 2.	Proportions of omitted sentences by response type	23
Figure 3.	Mean length of utterance (in morphemes) by word class and frequency	23
Figure 4.	Clauses per sentence by diagnostic group	24
Figure 5.	Clauses per sentence by diagnostic group and word class	24
Figure 6.	Clauses per sentence by frequency, meaning, and word class	25
Figure 7.	Sentence Complexity Index points per sentence by diagnostic group	25

BACKGROUND

The developmental profiles of young children with autism spectrum disorders (ASD) and children with specific language impairment (SLI) are both well-studied. Recently, research has focused on areas of overlap between these groups. Our study examines overlap in the developmental profiles of children with SLI and children with ASD in the area of complex syntax. Specifically, we seek to discover what syntactic characteristics older school-age children in both diagnostic groups share when asked to formulate a sentence around a target word.

Children with SLI are defined by language impairments in the absence of any diagnosis that would explain delayed language, such as a sensory deficit, neurological dysfunction, motor deficit, or mental retardation (Leonard, 1998). Compared to age-peers, children with SLI display shorter utterances and are more likely to omit obligatory noun and verb inflections in spontaneous language (Bedore & Leonard, 1998). Language of children with SLI is not simply time-delayed compared to age-peers: children with SLI also omit grammatical inflections more often than younger, normally developing children who create sentences of similar length (Leonard, Bortolini, Caselli, McGregor, & Sabbadini, 1992; Rice & Wexler, 1996). Overall, language profiles of children with SLI are characterized by marked difficulty with morphosyntax, moderate difficulty with semantics, and unimpaired or mildly impaired phonology (Tomblin & Zhang, 1999). These syntactic delays persist into adolescence and adulthood (Mawhood, Howlin, & Rutter, 2000; Marinellie, 2004).

As children grow, research highlights specific differences in use of complex syntax both over time and between children with and without language impairments. As school-age children without language impairment grow, their sentences exhibit increased clause density (Loban, 1976), increased mean length of T-unit, and more frequent use of relative clauses (Nippold, Hesketh, Duthie, & Mansfield, 2005). Compared to unimpaired peers in the same grade, school-age children with SLI used fewer complex sentences in conversation, and these

complex sentences tended to have fewer clauses (Marinellie, 2004), and fewer total words (Scott & Windsor, 2000) than their peers' complex sentences. Children with SLI also make more errors in complex syntax than their age-peers (Dykes & Schuele, 2002; Gillam & Jonston, 1992; Scott & Windsor, 2000).

To summarize: as children with SLI grow, they exhibit increases in the complexity of their syntax. However, they still display less use of and more errors in complex syntax compared to age- and grade-peers.

In contrast to children with SLI, children with ASD are defined by primarily social and pragmatic deficits in their use of language. In years past, the American Psychiatric Association's (APA) diagnostic criteria for autism required that an early language delay be present. Current criteria, however, require the presence of pragmatic deficits and/or the presence of delayed functional language, but do not require both (APA, 2000). In conversation, children with ASD tend to make frequent irrelevant and perseverative comments. They display difficulty with discourse initiation and termination, topic maintenance and shifting, and interpreting the needs and desires of their listeners. Excessively rigid interaction routines also make communication with peers difficult (Capps, Kehres, & Sigman, 1998; Fay & Schuler, 1981; Tager-Flusberg, 1999; Wilkinson, 1998). Research suggests that, like syntactic impairments in SLI, these pragmatic deficits also persist into adolescence and adulthood, and may even become worse with age (Mawhood, Howlin, & Rutter, 2000).

Research into the overlap between these two diagnostic groups suggests that children with autism display heterogeneous language profiles ranging from age-typical to severely impaired (Kjelgaard & Tager-Flusberg, 2001; Norbury, 2005); these language deficits appear to relate to social ability as measured by formal tests and informal observations (Eigsti, Bennetto, & Dadlani, 2007; Joseph, Tager-Flusberg, & Lord, 2002). Thus, we can offer the hypothesis that, whereas not all children with ASD have structural language impairment, a subgroup of children exists with characteristics of ASD and with structural language

impairment.

While many studies have investigated the structural language of children with pre-existing autism diagnoses, Bishop and Norbury (2002) isolated a subgroup of children from a pool of subjects with established structural language impairments. These researchers drew subjects from schools for children with language impairment and evaluated their pragmatic communication abilities. A subgroup of children emerged who not meet diagnostic criteria for autism but displayed pragmatic language deficits. Intriguingly, another subgroup of children emerged who did not display pragmatic deficits per parent report but who carried "autism-related diagnoses" including "atypical autism" and Asperger's syndrome. The authors suggested the possibility of a unique diagnostic category with similarities to both SLI and autism, as well as the possibility of a spectrum of ability in both pragmatics and language structure.

Longitudinal studies of children with SLI and children with autism show increasing similarities in both groups with age. Children with SLI begin to show difficulty with social language as they grow older, and children with autism continue to display disordered language as a whole with a wide variety of abilities, as predicted by other studies. Thus, we see an area of overlap between structural language impairment and pragmatic impairment (e.g.: Mawhood, Howlin, & Rutter, 2000).

Children with ASD who do exhibit structural language impairment exhibit linguistic profiles that are at least superficially similar to those of children with SLI. Young children with ASD show specific syntactic deficits when compared to typical and developmentally delayed controls matched by vocabulary (Eigsti, Bennetto, & Dadlani, 2007). Older children with ASD who score as impaired or borderline-impaired on several standardized tests of vocabulary, articulation, and syntax show linguistic profiles similar to those typical of SLI: articulation relatively unimpaired, vocabulary mildly impaired, and syntax more severely impaired (Kjelgaard & Tager-Flusberg, 2001). When the same children were compared to children with SLI on a verb tense-marking task, they showed similar error profiles but worse

overall performance compared to age-peers with SLI (Roberts, Rice, & Tager-Flusberg, 2004).

Research is united on the fact that children with SLI and children with ASD exhibit overlapping symptoms, likely including a subgroup of children with ASD that exhibit structural language impairments and possibly including a subgroup of children with SLI who exhibit pragmatic impairments. What remains unknown is whether the similarities between these two clinical categories reflects a shared phenotype or whether it is merely superficial. To address this gap in the knowledge base, in the current study, we explored the similarities of their syntactic profiles in more detail.

Current Study

Previous research has largely focused on subjects with autism that are much younger or much older than the population investigated here (e.g.: Eigsti, Bennetto, & Dadlani, 2007; Mawhood, Howlin, & Rutter, 2000). Previous data involved primarily narrative language (e. g.: Gillam & Johnston, 1992; Marinellie, 2004), or standardized tests (e.g.: Norbury, 2005). In the current study, we asked older school-age children to formulate sentences around a target word. This is an environmentally relevant task for school-aged children, who are asked to perform similar tasks in academic settings.

Formulating a sentence around a given target word required the children to integrate semantic and syntactic knowledge in a complex manner. Therefore, with this task, we were able to address the following: how do older school-age children in different diagnostic subgroups perform in terms of syntactic complexity? Do high functioning children on the autism spectrum who show no concomitant structural language impairment on a standardized test nevertheless show impairments on a task that requires complex integration of semantic and syntactic knowledge?

Word definition tasks are another method for investigating the integration of syntactic and semantic knowledge. Like the current study, studies of word definitions can

relate responses directly to word variables. The current study looks at word class, word frequency, and word meaning, so we look to previous research into these variables.

Research into word definitions indicates that children and young adults with age-typical language provide less complex definitions for low-frequency compared to high-frequency words (Marinellie & Chan, 2006; Marinellie & Johnson, 2003) and for verbs compared to nouns (Marinellie & Johnson, 2004). Children with SLI provide less content and use simpler forms in their definitions compared to age-peers without language impairment (Marinellie & Johnson, 2002).

Although our sentence generation task differs from word defining, both require an integration of semantic and syntactic knowledge. Thus, it would be reasonable to expect that our subjects would show similarities in the sentences produced; i.e.: less complex sentences for low-frequency words compared to high-frequency words, and for verbs compared to nouns. It is also reasonable to expect less-complex sentences produced by children with language impairment compared to their unimpaired peers.

While word-definition studies do not directly investigate the impact of word frequency on children with language impairment, research has documented deficits with low-frequency words compared to high frequency words in word recall (Mainela-Arnold & Evans, 2005) and in verb inflection (Norbury, Bishop, & Briscoe, 2001; Marchman, Wulfeck, & Ellis Weismer, 1999). This indicates that we can expect children with language impairment to show a broader gap between low- and high-frequency words compared to peers.

The current study also divides words based on their abstract or concrete nature. Intuition suggests that abstract words would be more difficult than concrete, and psycholinguistic theory and research supports this. According to Gleitman, Cassidy, Nappa, Papafragou, & Trueswell (2005), abstract words are more difficult to acquire than concrete words. While earlier theories suggested that this was due to underdeveloped understanding of the concepts behind abstract words, research into adult models shows that this is not the case

(e.g.: Gillette, Gleitman, Gleitman, & Lederer, 1999), but rather that acquisition of abstract words requires a higher level of linguistic knowledge. According to this research, concrete words can be learned by observation, which allows for linkage of a specific word to its most frequently related object or situation. After a “base” of concrete words has been acquired, the language learner must use these words and their position in a sentence in combination with contextual observation to understand the meanings of abstract words. This process is known as “syntactic bootstrapping:” using the syntax surrounding a novel word to understand its meaning. Since the semantic properties of these words are more difficult to acquire and our task requires an integration of semantic and syntactic knowledge, we can expect all groups to show more difficulty when formulating sentences with abstract compared to concrete words.

Since abstract words are learned via syntactic bootstrapping, and children with language impairment in this study are defined by syntactic impairments, we would expect them to have a wider abstract-concrete gap than unimpaired peers. Previous research supports this hypothesis: children with SLI have difficulties using syntactic bootstrapping to learn new words compared to age-peers, and even compared to peers with autism (Shulman, & Guberman, 2007). These children also tend to make errors in complex syntax with more abstract verbs, which require syntactic bootstrapping to acquire and understand (King, 1993). According to McGregor, Berns, Owen, and McConnell (in preparation), in a precursor to the current study (employing the same participants), language-mates, children with SLI, and children with ASD plus structural language impairment all perform similarly to each other in defining words. They provide less complex definitions overall compared to age-mates and they include less information in definitions of abstract than concrete words.

The abstract-concrete gap and the verb-noun gap are not orthogonal because verbs as a whole are more abstract than nouns. Adults require more syntactic bootstrapping support to infer the referents of abstract words than concrete words and to infer the referents of verbs than nouns (Gillette, Gleitman, Gleitman, & Lederer, 1999).

Verbs require certain argument structures; that is, a given verb constrains the other

words that can be used in a sentence, where they can be located, and what role they can play. Different verbs have unique combinations of sentence structures in which they can be found. This is considered the intersection of semantics and syntax, since the argument structure of a verb is part of its lexical representation, but also involves a broader understanding of syntax (Bock & Levelt, 1994). Abstract verbs with complex argument structures are particularly difficult for children with SLI (e.g: Owen & Leonard, 2006). Overall, we tentatively expect all groups to perform more poorly with abstract than with concrete words, and the language-impaired groups to have a wider performance gap between abstract and concrete words. However, abstract verbs (e.g.: those that represent mental states, communication, or desire) tend to have more complex argument structures than concrete verbs and nouns. Therefore, an alternative hypothesis is that children who are able to successfully use these abstract verbs will create more complex sentences with them than with concrete verbs and nouns.

This study seeks to explore the overlap between autism spectrum disorders and specific language impairment characterized by the syntactic complexity of sentences in response to specific target words. We ask: Do children with ASD and structural language impairments perform similarly to children with SLI? That is, do they fit the double-deficit model of SLI “on top of” ASD? Do children with ASD without structural language impairment perform similarly to age-mates, or do they too show impairments when their language system is sufficiently taxed? How do children with structural language disorders, regardless of ASD diagnosis, perform compared to younger, typically-developing language-mates? How is syntactic complexity affected by the type of word presented as a target? Based on previous research, we offer several hypotheses:

1. Children with structural language impairment, regardless of any autism diagnosis, will have similar abilities in creating complex sentences and will create less complex sentences compared to their age-mates.
2. Children with high-functioning autism without concomitant structural language impairments will create sentences of comparable complexity to their age-mates.

3. Children in all diagnostic groups will create less-complex sentences in response to low-frequency words compared to high-frequency words, in response to verbs compared to nouns, and in response to abstract compared to concrete words.
4. When compared to age-peers, children with structural language impairment, regardless of autism diagnosis, will show a wider gap in syntactic complexity between sentences created with verbs and those created with nouns, between those created with low-frequency compared to high-frequency words, and between those created with abstract compared to concrete words.

METHODS

Following is a description of subjects and stimuli as presented in McGregor et al. (in preparation).

Subjects

A total of 123 subjects were recruited. These were divided into four groups: autism without language impairment (ASD) (n=20; mean age 11;0), specific language impairment (SLI) (n=14; mean age 10;8), autism and language impairment (ASD+LI) (n=12; mean age 11;0), or normal development. Those with normal development were matched to the impaired groups on either age (AM) (n=51; mean age 10;8) or language ability (LM) (n=26; mean age 7;6).

All participants had normal hearing acuity and normal nonverbal intelligence as determined by passing scores on a pure-tone hearing screening administered per ASHA (1990) guidelines and standard scores of at least 85 on the matrices subtest of the Kaufman Brief Intelligence Test-2 (KBIT2, Kaufman & Kaufman, 2004), respectively.

The ASD group was composed of 19 boys and 2 girls, each of whom was included on the basis of an independent diagnosis of and services for ASD via parent report and scores on the Autism Diagnostic Observation Schedule (ADOS, Lord, Rutter, DiLavore, & Risi, 1999) and the Social Communication Questionnaire (SCQ, Rutter, Bailey, Berument, Lord, Pickles, 2003) that met cutoffs for autism spectrum or autism disorders.

The SLI group was composed of 9 boys and 5 girls, each of whom was included on the basis of an independent diagnosis of and services for oral or written language impairment via parent report (with the exception of one child who did not receive services because he was home-schooled) and average scaled scores of 7 or less on the Formulated Sentences and Recalling Sentences subtests of the Clinical Evaluation of Language Fundamentals-4 (CELF4, Semel, Wiig, & Secord, 2003). Finally, to be included in the SLI group, a child had

to score outside of the range of autism spectrum (lower than 11) on the SCQ.

The ASD+LI group comprised 11 boys. These children met the same inclusionary criteria as those in the ASD group and, like the SLI group, they had average scaled scores of 7 or lower on the Formulated Sentences and Recalling Sentences subtests of the CELF4.

The AM group was composed of 27 boys and 24 girls. The LM group was composed of 14 boys and 12 girls. To be included in either the AM or LM group, a child had to achieve a standard score of at least 85 on the CELF4 core battery had to score outside of the range of autism spectrum (lower than 11) on the SCQ.

Demographic information and standardized test data for all participant groups are summarized in Appendix A along with between-group comparisons of these data. Following Mervis and Robinson (2003), we sought to match the AM group to the clinical groups on the basis of age such that statistical comparisons yielded *p* values of at least 0.50. Likewise, we ensured that the LM group was well matched to the two clinical groups with limited syntax, SLI and ASD+LI, by comparing the sum of their raw scores on the Formulated Sentences and Recalling Sentences subtests of the CELF4 and finding *p* values of 0.50 or greater. Of course the SLI and ASD+LI groups were chosen because they have poorer syntactic abilities than their AM peers and this too is illustrated in Appendix A. Likewise, because only the ASD and ASD+LI groups should score in the autism spectrum range of the SCQ, we expected and found significant differences between these groups and all other groups on this measure.

Several other constructs, including maternal education, working memory, nonverbal intelligence, receptive and expressive vocabulary, and overall receptive and expressive language, were also measured for each subject. As these constructs may impact language ability as measured by this study, means, standard deviations, and cross-group comparisons for these items are also available in Appendix A.

Stimuli

Stimulus words were selected from *The Educator's Word Frequency Guide* (Zeno, Ivens, Millard, & Duvvuri, 1995) to represent nouns and verbs of high and low frequency and abstract and concrete meanings. This database was chosen because it evaluates the relative frequency of words in texts for school-aged children.

Potential stimulus words were designated concrete if their referents were readily observable objects or actions. Words were designated abstract if their referents were less readily observable; these were nouns and verbs that described mental states, feelings, acts of communication, or events. The authors' impressions of whether the dominant meaning of a word was a noun or verb and whether it was abstract or concrete were confirmed by a group of 10 adults, and any item that did not have 90% or better agreement was discarded. Thus, for example, the word "farm" was included as a concrete noun based on adult ratings even though it can be used as a verb.

Frequencies were calculated for the word and all variants within the word class (e.g., *stretch, stretches, stretched*, and *stretching* values were added to form a total value for *stretch*) using the U score, which calculates N per million words, weighted by their dispersion across texts (see Zeno et al., 1995, p.15 for details). Because items were chosen based on word frequencies, the frequency difference between high and low groups was significant, $F(1,32) = 76.07$, $p < 0.0001$, $\eta_p^2 = 0.70$, but there was no frequency difference between nouns and verbs, $F(1,32) = 0.15$, $p = 0.70$, nor between concrete and abstract words, $F(1,32) = 0.0004$, $p = 0.98$. There were also no significant interactions.

To summarize, the resulting stimulus set contained 40 words comprising 8 sets of 5 words defined by crossing frequency (high and low), word class (noun and verb) and meaning (concrete and abstract). A complete list of words is presented in Appendix B.

Data Collection

Each child was asked to produce a sentence using each of the above-described 40 words. These words were presented in a randomized order with instructions to make a sentence using that word. Children were allowed to “pass” if they did not know the word. Complete task instructions are presented in Appendix C.

All sentences produced were audio-recorded and transcribed live. These transcripts were then transcribed into the Systematic Analysis of Language Transcripts software (SALT, Miller, 2004). Twenty-two subjects did not have audio recordings of their sessions at the time of transcription and coding. In these instances, the transcriber relied on handwritten transcriptions taken by the examiner at the time of testing.

The reader may be concerned that the experimental task is too similar to one of the measures used to classify subjects, namely, the Formulating Sentences subtest of the CELF4. In fact, these tasks differ in several important ways. The first is the nature of the target words used: the CELF4 task uses conjunctions and adjectives of gradually increasing complexity while this study uses nouns and verbs that are relatively consistent in underlying complexity (see Appendix B). Secondly, the CELF4 task asks the child to create a sentence using a target word that is also about specific subject matter, namely, a picture shown to the child. In contrast, our task puts no limit on the content of the elicited sentence. Finally, and most importantly, these protocols do not analyze the same factors: the CELF4 assesses use of the target word, correct description of the picture, and any grammatical errors. Our task does not assess content and further assesses syntactic complexity beyond the presence or absence of errors. Thus, while the two tasks are alike enough to likely measure similar underlying constructs, they are not so alike as to be repetitive.

Only one sentence per target word was recorded for later coding. Determining when a sentence ended was difficult for some subjects. Ultimately, a system combining prosodic and structural cues was implemented: a sentence ended when a sufficient pause (based on each child’s previous behavior) occurred that was not followed by more verbage preceded by a

conjunction (and, but, etc) or when a sufficient pause with examiner speech occurred. For example, if a child said: “I obey the law (lengthy pause) and so does my dad” the entire sentence would be transcribed. If a child said: “I obey the law (lengthy pause) once my dad got a ticket for speeding,” then only “I obey the law” would be transcribed since the verbage after the pause did not begin with a conjunction. This was an important distinction, since many children exhibited perseverative behaviors and could talk about each prompt at length.

When a child’s pause was long enough that the examiner spoke, no verbage after the examiner speech was recorded even if it began with a conjunction. We assumed that since the examiner used additional cues (body language, eye gaze) to determine that the sentence was complete, the child was being perseverative if he or she continued to talk about the prompt after examiner speech.

Twenty-five recordings (20% of total) were transcribed by both the author and a lab assistant to establish transcription reliability. These recordings represented all groups. Reliability on number of complete and intelligible utterances ranged from 97-100%, with an average of 99%. For number of mazes, reliability ranged from 20-100%, averaging 89%. Reliability for maze boundaries ranged from 63-100%, with an average of 93%. Reliability for number of morphemes averaged 98%, with a range of 86-100%, and morpheme type reliability ranged from 92-100%, averaging 97%. Low values for some transcripts on number of mazes and maze boundaries were due to very few (five or fewer) mazes per transcript, thus amplifying the impact of any disagreements. Despite occasional “low transcripts,” interrater agreement across all measures was above 85%, and averaged 95%. After reliability was established, the remaining recordings were transcribed by the lab assistant.

Coding

To investigate syntactic complexity, the sentences were coded using the Sentence Complexity Index (Scott & Lane, 2008). The Sentence Complexity Index (SCI) was developed for the purpose of evaluating syntactic development in older children and

adolescents, and the coding key was presented to our lab via personal communication from C. Scott. Dr. Scott developed the SCI after extensive analysis of a database of written and spoken language samples from 11-year-old children with and without language impairment and 9-year-old language mates. The code assigns any sentence a point value based on the number and type of clauses, with each clause identified by the presence of a verb. Based on analysis of the language database, this system further quantifies syntactic complexity by assigning higher point values for later-developing structures, including multiple clauses, embedded clauses, and clauses reflecting the impact of literacy. For a complete list of codes and point values, see Appendix D.

A few changes were made to the SCI to make it easier to use for our purposes. Firstly, since the SCI was designed for use with language samples broken into C-units, it did not have scoring protocols for coordinated clauses with subjects. Since these constructions represent a lower level of complexity than coordinated clauses with subject elision, these clauses were coded as “coordinated clause with subject” codes, and scored by level of embedding in the same manner as coordinated clause codes, but minus one point. Secondly, a code was added to indicate a main verb in a sentence fragment.

For example, a complex sentence such as: “The mom that picks up (her) the kids says ‘What's the purpose of running away from school without getting your food?’” would receive a code for every verb, based on the type of clause it was in. This would look like this: “The mom that pick/3s[v1RCE] up (her) the kid/s say/3s[v] ‘What/'cs[v1Q] the purpose of run/ing[v2VC] away from school without get/ing[v3AL] your food?’.” This sentence earned a total of nine points (see table 1).

Simpler sentences received fewer points. For example, the sentence: “I wanted to eat because I was hungry” would also receive a code for every verb which varied by clause. The codes would be: “I want/ed[v] to eat[v1VCNF] because I cwas[v2A] hungry.” This sentence only earned a total of 2.5 points (see table 2).

Twenty-six transcripts (21% of total) were coded by both the author and a lab

assistant to establish point-to-point reliability for SCI codes. These transcripts represented all subject groups. Interrater reliability ranged from 82% to 100%, with an average value of 93%. After reliability was established, the remaining transcripts were coded by the author.

Omitted Sentences

Not every prompt resulted in a sentence. When children responded to a prompt with "I don't know," a sentence that did not include the target word, or a phrase including that target word that was not a sentence (i.e., because it did not include a verb), this was coded as an "I don't know" response. When a sentence used the word as a brand name or as a different part of speech, these were coded as "wrong word class." Both "I don't know" and "wrong word class" were excluded from the analysis.

Data Analysis

After transcribing and coding all sentences using the SALT software, individual transcripts of up to 40 sentences were broken into 8 mini-transcripts, each with a different permutation of word class, frequency, and meaning (e.g.: high-frequency, abstract verbs; high-frequency, abstract nouns; low-frequency, abstract verbs, et cetera).

All SCI codes were then counted for each subject and each word category (e.g.: all codes for all acceptable sentences made using high-frequency, abstract nouns as target words). Initial analysis looked at the number of sentences produced for each word type, and all further analyses divided the variable of interest by the number of sentences produced.

Mean length of utterance (MLU) in morphemes was also calculated for these sentences. Although some research suggests that this is not a valid measure of syntactic complexity in older school-age children (Klee & Fitzgerald, 1985; Scarborough, Wickhoff, & Davidson, 1986), we were interested to see if it varied according to target word type.

Table 1: Example one syntactic codes, description, and point value for each

Code	Level	Code Type	Points
[v1RCE]	one	center-embedded relative clause	2
[v]	main	main verb	0
[v1Q]	one	Quotation	1
[v2VC]	two	verb complement clause	2
[v3AL]	three	adverbial clause, late-developing conjunction	4

Table 2: Example two syntactic codes, description, and point value for each

Code	Level	Code Type	Points
[v]	main	main verb	0
[v1VCNF]	one	verb complement clause, non-finite	0.5
[v2A]	two	adverbial clause, early-developing conjunction	2

RESULTS

After codifying the complexity of sentences produced, we analyzed differences between and within groups. Several general linear models were set up; all used group as a categorical predictor and raw scores on the Kaufman Brief Intelligence Test (KBIT) as a continuous predictor, as groups were poorly matched on this variable.

To foreshadow, significant between- and within-group differences were seen in number of acceptable sentences produced (i.e., sentences that included a verb), mean length of utterance, number of clauses per sentence, and number of points per sentence. Points per sentence utilized the Sentence Complexity Index to weight clauses according to the different levels of language development they reflect, whereas clauses per sentence treated all different types of clauses equally. For each significant difference, we report effect size as partial eta-squared (η_p^2).

Acceptable Sentences Produced

Because only certain sentences were acceptable for analysis, we took the preliminary step of determining whether the groups differed in overall number of acceptable sentences. A one-way ANCOVA with the KBIT raw scores as a covariate and number of acceptable sentences produced as the dependent variable yielded an effect of the covariate, $F(1, 117)=5.45$, $p=.02$, $\eta_p^2=.04$.

There was a main effect for diagnostic group, $F(4, 117)=2.95$, $p=.02$, $\eta_p^2=.09$. Post hoc testing using Tukey's unequal N honestly significant difference revealed that the LM group produced fewer acceptable sentences than all other groups save the SLI group, *p*s $\leq$ .04; SLI: p=.31; there were no other between group differences (see Figure 1). Because of the number of acceptable sentences did vary across groups, all subsequent variables – mean length of utterance, point density, and clause density – were calculated by dividing the variable of interest by the total number of acceptable sentences produced for each child.

Omitted Sentences

A total of 567 unacceptable sentences (out of a possible 4920) were omitted from analysis. Not all subjects produced unacceptable sentences, but all groups produced some (average sentences per subject: AM=2.86; LM=8.23; SLI=5.21; ASD=4.10; ASD+LI=4.25). These involved sentences of two sorts: those in which the child used the target word but as a different word class than anticipated ("wrong word class," e.g., “I'm on a walk” when “walk” was classified as a verb); and those targets for which there was no response ("I don’t know”).

For the AM, ASD, SLI, and ASD+LI groups, the proportion of these two errors was 60-70% wrong word class and 30-40% no response. For the LM group, these proportions were reversed, with 67% being no responses and 32% being wrong word class responses (see Figure 2).

The reader may notice in Figure 2 that the proportion of “no response” sentences for the SLI and ASD+LI groups appear different. A *t*-test for these two proportions showed that they were not significantly different, p=.42. Thus, while groups differ on their number of acceptable and unacceptable responses, all groups except the language mates show relatively uniform reasons for not producing sentences.

Mean Length of Utterance

Main effects. A 5(diagnostic group) x 2(word frequency) x 2 (word class) x 2(word meaning) mixed model ANCOVA with repeated measures on the final three variables, KBIT raw scores as a covariate, and mean length of utterance in morphemes as the dependent variable yielded no effect of the covariate. There were also no main effects of group or word variables.

Interactions. No interactions between diagnostic group and word variables were found, only an interaction between word variables. The interaction between word class and frequency was significant, $F(1, 118)=4.56$, $p=.03$, $\eta_p^2=.04$. Post hoc analysis using Bonferroni’s test showed that sentences using high-frequency verbs had the lowest MLU

(*M*=7.68, *SE*=.26), significantly lower than low-frequency verbs (*M*=8.25, *SE*=.36), p=.01, and tending toward significantly lower than high-frequency nouns (*M*=8.39, *SE*=.23), p=.07 (see Figure 3). No similar relationships to these were described by other measures of syntactic complexity, and these findings actually contradict other measures (see below).

Clauses per Sentence

Main effects. A 5(diagnostic group) x 2(word frequency) x 2 (word class) x 2(word meaning) mixed model ANCOVA with repeated measures on the final three variables, KBIT raw scores as a covariate, and mean clauses per sentence as the dependent variable yielded no effect of the covariate.

There was a significant effect of diagnostic group, $F(4, 118)=3.77$, p=.006, $\eta_p^2=.11$. As predicted by our hypotheses, planned comparisons revealed that the SLI (*M*=1.40, *SE*=.09) and ASD+LI (*M*=1.50, *SE*=.10) groups produced sentences with lower clause density than the AM (*M*=1.71, *SE*=.05) and ASD (*M*=1.81, *SE*=.08) groups, *p*s< .04. The SLI, ASD+LI, and LM (*M*=1.51, *SE*=.07) groups did not differ, *p*s > .46, nor did the ASD and AM groups, p=.27 (see Figure 4).

The main effect for word class was significant, $F(1, 118)=32.64$, p<.001, $\eta_p^2=.22$. Post hoc testing using Bonferroni's measure showed that, contrary to our hypothesis, subjects had higher clause density with verbs (*M*=1.70, *SE*=.05) than with nouns (*M*=1.48, *SE*=.03).

A significant effect for meaning was also found, $F(1, 118)=19.06$, p<.001, $\eta_p^2=.14$. Post hoc analysis with Bonferroni's test revealed that subjects had higher clause density with abstract words (*M*=1.67, *SE*=.04) than with concrete (*M*=1.51, *SE*=.03), which contradicts our expectations outlined in our hypotheses.

Interactions. The above main effects are qualified by interactions between variables. Because group and word variable interactions are predicted by our hypotheses, we present these first, followed by interactions between word variables. A significant interaction between word class and diagnostic group was found: $F(4, 118)=2.75$, p=.03, $\eta_p^2=.09$ (see

Table 3 and Figure 5). As predicted by our hypothesis, Bonferroni's test during post-hoc analysis showed that the AM group had higher clause density for verbs (*M*=1.91, *SE*=.06) than the SLI group (*M*=1.49, *SE*=.12), p=.02 and the LM group (*M*=1.59, *SE*=.09), p=.03. The differences for verbs between ASD+LI and SLI groups and between the AM and ASD groups were not significant, *p*s=1.00. Contrary to our hypothesis, the difference between the AM and ASD+LI (*M*=1.59, *SE*=.13) groups for verbs was not significant, p=.50.

Contrary to our hypothesis, clause density for verbs in the AM group was higher than that for nouns in the AM group (*M*=1.52, *SE*=.05), p<.001. Clause density for verbs was not significantly higher than clause density for nouns in any other group.

We now turn to interactions between word variables. The interaction between word class, frequency, and meaning was significant, $F(1, 118)=6.00$, p=.02, $\eta_p^2=.04$ (see Table 4 and Figure 6). Post hoc analysis using Bonferroni's test showed more complex interactions that aligned with the word variable main effects discussed above. Contrary to our predictions, subjects produced the most clauses per sentence for low-frequency abstract verbs (*M*=1.83, *SE*=.11), followed closely by high-frequency abstract verbs (*M*=1.79, *SE*=.05). Subjects produced more clauses per sentence for low- and high-frequency abstract verbs than they did for all noun types: high- and low-frequency, abstract and concrete. Clauses per sentence for low- and high-frequency abstract verbs were also higher than low-frequency concrete verbs (*M*=1.53, *SE*=.05), p<.001 and p=.02, respectively.

All between-noun comparisons were at *p*s>.75 except for high-frequency abstract nouns compared to high-frequency concrete nouns. Subjects made significantly fewer clauses for high-frequency concrete nouns (*M*=1.38, *SE*=.04) than with high-frequency abstract nouns (*M*=1.57, *SE*=.04), p=.005.

All comparisons between high- and low-frequency words (e.g.: high-frequency abstract nouns vs. low-frequency abstract nouns, high-frequency concrete verbs vs. low-frequency concrete verbs, etc) yielded *p*s=1.00.

Points per Sentence

Main effects. A 5(diagnostic group) x 2(word frequency) x 2 (word class) x 2(word meaning) mixed model ANCOVA with repeated measures on the final three variables, KBIT raw scores as a covariate, and mean SCI points per sentence as the dependent variable yielded no effect of the covariate.

Initial analysis of Sentence Complexity Index (SCI) scores per sentence revealed a significant effect of group: $F(4, 118)=3.79$, $p=.006$, $\eta_p^2=.11$. As predicted, univariate tests of significance for planned comparison showed that the SLI group had fewer points per sentence ($M=.42$, $SE=.13$) than the AM group ($M=.81$, $SE=.07$), $p=.001$, and the ASD group ($M=.95$ $SE=.10$), $p=.002$. The ASD+LI group also had fewer points per sentence ($M=.55$, $SE=.14$) than the AM group, $p=.03$, and the ASD group, $p=.02$. Further confirming our hypotheses, the differences between both the ASD+LI and the SLI groups and the language mates ($M=.48$, $SE=.09$) were not-significant, $p=.70$ and $p=.75$, respectively. The difference between the ASD and AM groups were also not significant, $p=.25$ (see Figure 7).

A significant effect was found for word class, $F(1, 118)=10.15$, $p=.002$, $\eta_p^2=.08$. Contrary to our predictions, subjects had more points per sentence for verbs ($M=.77$, $SE=.08$) than nouns ($M=.56$, $SE=.05$).

The effect of meaning was also significant, $F(1, 118)=10.88$, $p=.001$, $\eta_p^2=.08$. Subjects had higher average SCI scores for sentences with abstract words ($M=.77$, $SE=.07$) than with concrete words ($M=.56$, $SE=.05$).

No significant interactions were found for SCI scores.

Table 3: Within-group comparisons of clause density by word class

Group	Word Class	M	SE	p value
ASD	noun	1.73	.07	p=1.00
	verb	1.89	.10	
LM	noun	1.42	.07	p=.92
	verb	1.59	.09	
SLI	noun	1.32	.09	p=1.00
	verb	1.49	.12	
ASD+LI	noun	1.40	.10	p=1.00
	verb	1.59	.13	

Table 4: Comparisons of clause density by word class, frequency, and meaning

Word Type	M	SE	p vs LAV	p vs HAV
HAN	1.57	.04	*p<.001*	*p<.01*
HCN	1.38	.04	*p<.001*	*p<.001*
LAN	1.51	.06	*p<.001*	*p<.001*
LCN	1.47	.04	*p<.001*	*p<.001*

Note: H=high-frequency, L=low-frequency, C=concrete, A=abstract, V=verb, N=noun

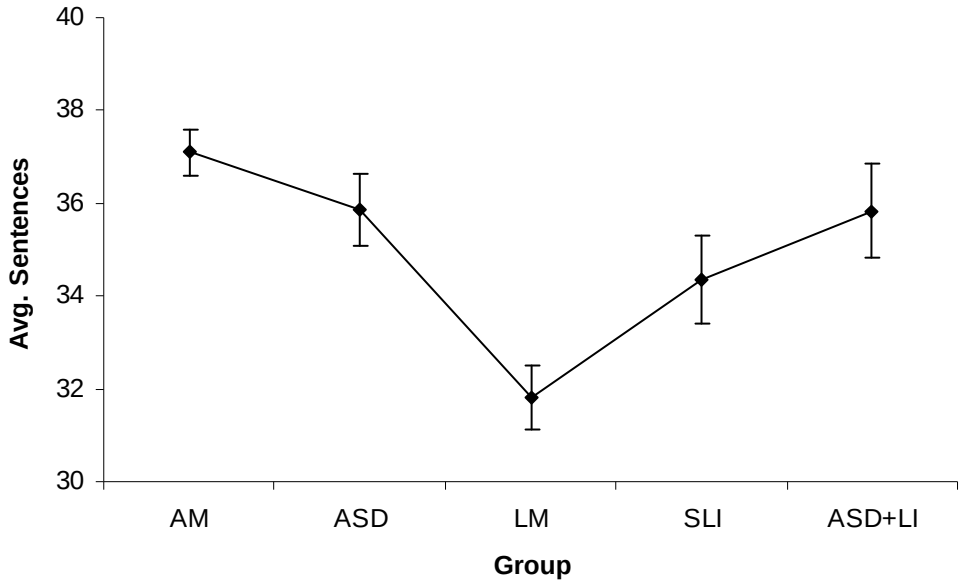

Figure 1: Acceptable sentences by diagnostic group

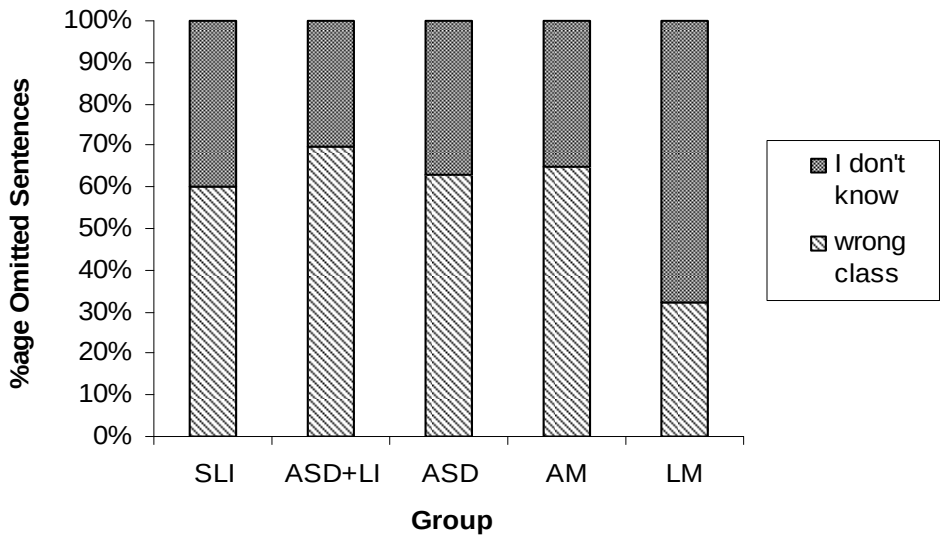

Figure 2: Proportions of omitted sentences by response type

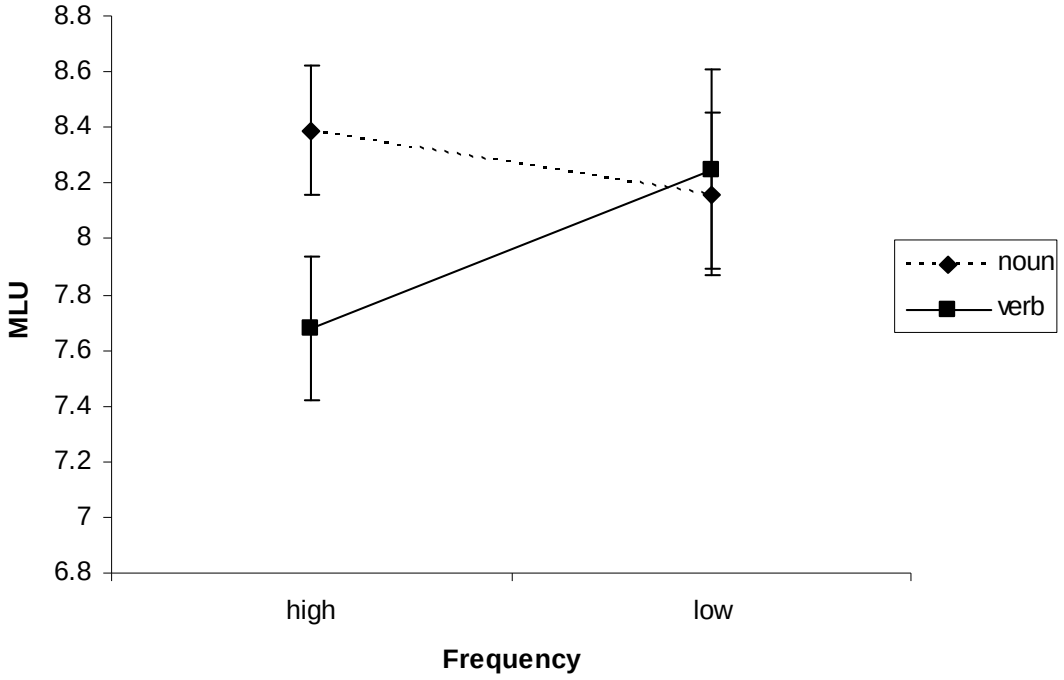

Figure 3: Mean length of utterance (in morphemes) by word class and frequency

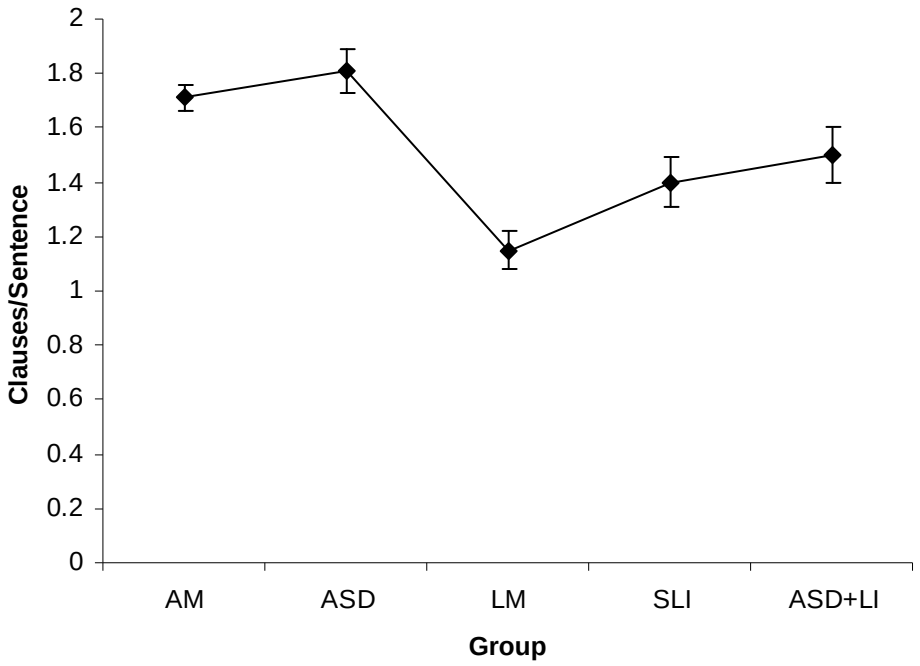

Figure 4: Clauses per sentence by diagnostic group

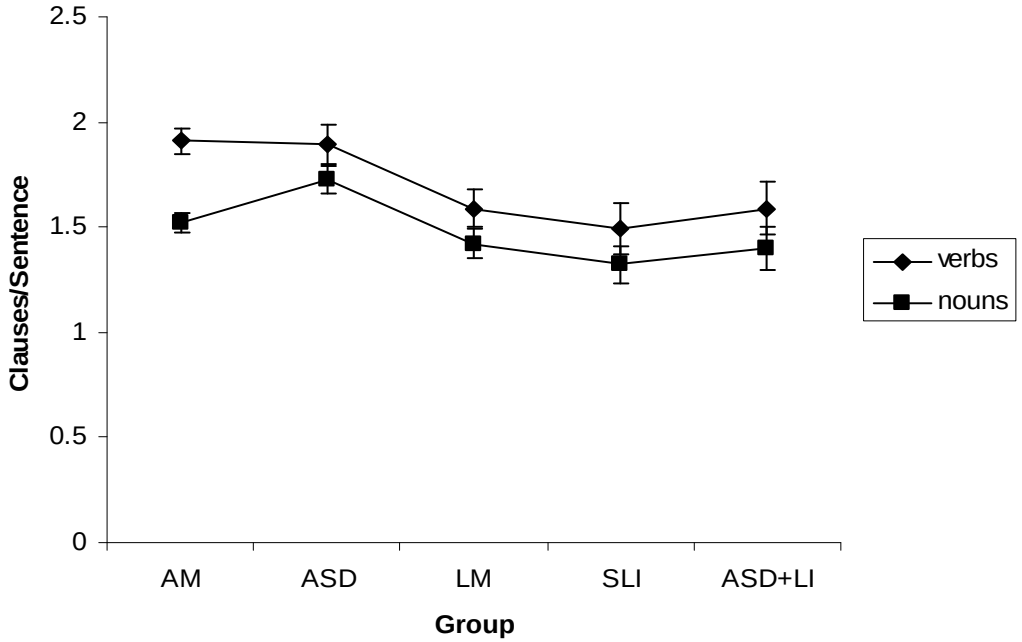

Figure 5: Clauses per sentence by diagnostic group and word class

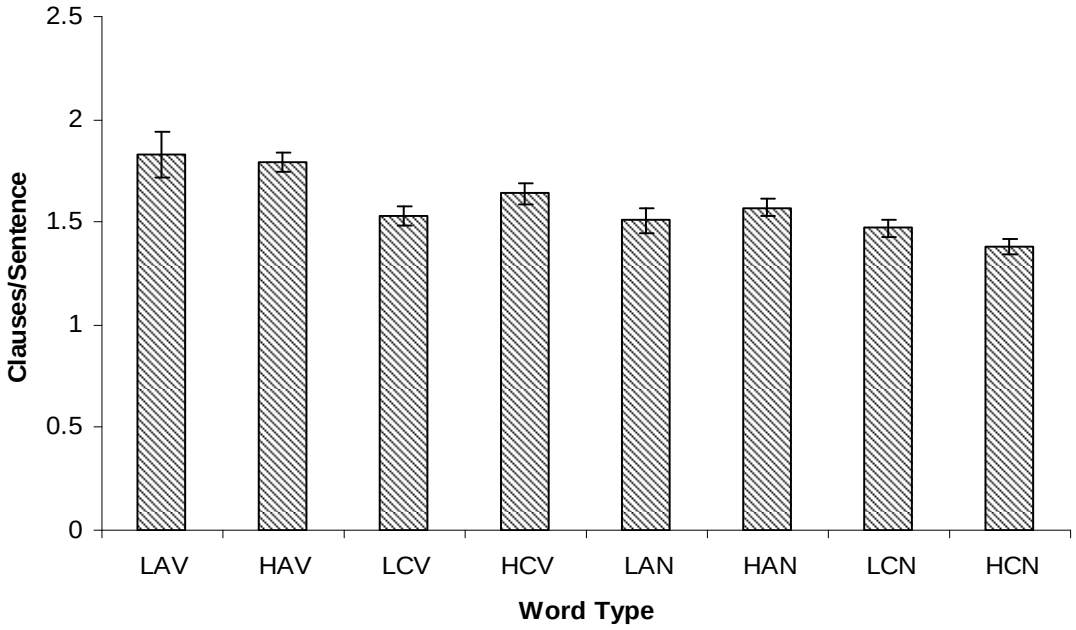

Figure 6: Clauses per sentence by frequency, meaning, and word class

Note: H=high-frequency, L=low-frequency, C=concrete, A=abstract, V=verb, N=noun

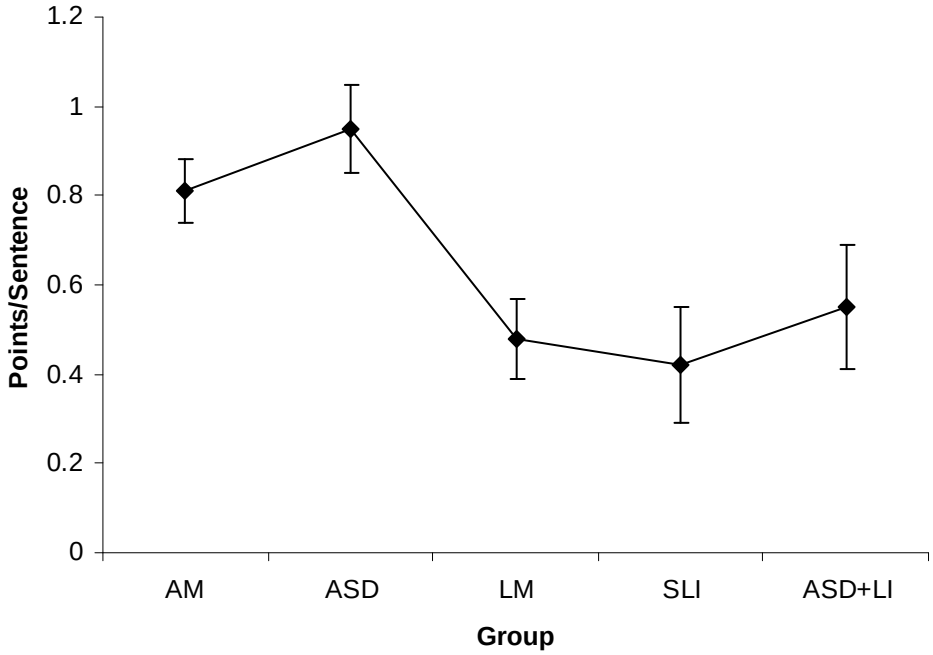

Figure 7: Sentence Complexity Index points per sentence by diagnostic group

CONCLUSIONS

Our study investigated the syntactic complexity of sentences created by children in response to a specific target word. The children were divided into five groups: those with specific language impairment, those with high functioning autism spectrum disorder, those with high functioning autism spectrum disorder plus structural language impairment, and controls matched by age or language ability. The target words were divided into eight groups by crossing word class (noun or verb), meaning (concrete or abstract), and frequency (low or high). In accordance with earlier research, we made several hypotheses regarding the syntactic complexity of sentences in relation to these variables. These hypotheses and our results are presented below.

1. Children with structural language impairment will have similar abilities in creating complex sentences, regardless of any autism diagnosis, and will create less complex sentences compared to their age-mates.

The pattern in complex sentence production shows the similarities between children with SLI and children with ASD plus structural language impairment that we hypothesized: the SLI and ASD+LI groups are rarely different from each other or from the language mates and they were both lower on the clause density and points density measures than their age mates. The three exceptions were that the ASD+LI and SLI groups did not differ from the AM group on number of acceptable sentences, types of unacceptable sentences (i.e., they produced similar proportions of “no response” and “wrong word class” responses), or MLU. However, unlike clause density and point density, none of these three were direct measures of sentence complexity.

2. Children with high-functioning autism without concomitant structural language impairments will create sentences of comparable complexity to their age-mates.

When investigating the data for the ASD group, our results do not suggest a “hidden” language deficit that was teased out by our task. Rather, these children tend to perform as

their test scores would indicate and we hypothesized: similarly to age-mates without language impairment. These groups were not significantly different on number of acceptable sentences produced or on their proportions of “no response” and “wrong word class” responses, nor did they differ on their clause or point density scores.

We can conclude that children with ASD whose test results indicate no concomitant structural language impairment do not evince problems with complex sentence construction, even on a task that requires a sophisticated interaction of semantic and syntactic knowledge.

3. Children in all diagnostic groups will create less-complex sentences in response to low-frequency words compared to high-frequency words, in response to verbs compared to nouns, and in response to abstract words compared to concrete words.

We look first at word frequency. No main effects for frequency were found for any of our analyses. This immediately suggests that frequency did not have a robust effect on these children’s performance. When word class and meaning are added to frequency, the nature of the interaction is telling: the most clauses per sentence were made with low-frequency abstract verbs and high-frequency abstract verbs, and no significant differences were found between any combination of high- and low-frequency words. This suggests that word frequency can vary without effecting sentence production.

In terms of word class, our results refute our hypothesis. Subjects made more clauses per sentence with verbs than with nouns. They also earned more SCI points per sentence with verbs than with nouns. When word class interacted with frequency and meaning, subjects created more clauses per sentence with high- and low-frequency abstract verbs than with any nouns.

One exception to the above is mean length of utterance (MLU). In this measure, high-frequency verbs had the lowest score. This conflicts with more direct measures of syntactic complexity for this age group, and will be discussed later.

Finally, our hypothesis is again refuted when investigating the impact of word meaning on performance. Clauses and SCI points per sentence show that all groups displayed

better performance with abstract than with concrete words. When we investigate the interaction of word meaning with word class and frequency, we find that these children produced the most clauses per sentence for high- and low-frequency abstract verbs. This difference was significant for all concrete words save high-frequency concrete verbs.

This hypothesis requires substantial revision: word frequency does not seem to have an impact on complex sentence creation. Further, subjects actually performed more poorly with nouns than with verbs on all measures with significant differences, and performed more poorly with concrete than abstract words.

4. When compared to age-peers, children with structural language impairment (regardless of autism diagnosis) will show a wider gap in syntactic complexity between sentences created with verbs and those created with nouns, between those created with low-frequency compared to high-frequency words, and between those created with abstract compared to concrete words.

As explored above, the general trend in word class comparisons is one of poorer performance on nouns than with verbs. The age-mates produced significantly more clauses with verbs than with nouns. In contrast to our expectations, the number of clauses for verbs vs. nouns for both language-impaired groups and the language mates were not significantly different. Group and word variable interactions involving word frequency or meaning were not observed.

This study does not provide evidence to indicate that children with structural language impairment have a wider ability gap than peers between nouns and verbs, low- and high-frequency words, or abstract and concrete words.

Limitations of the Study

This study has some limitations which restrict how broadly the results may be interpreted.

The first is the nature of the task. While it displays environmental validity as a task

that children are frequently asked to perform in academic settings, its validity is limited to those settings. Also, it makes it difficult to compare this research to past research that focused on conversational or narrative language. Since the task is not as naturalistic as these other contexts, we may have missed some differences between our groups, especially those that might be elicited in more challenging pragmatic contexts

Further, because we required children to respond using each target word as its predetermined word class in order for the sentence to be analyzed, it was possible for children to make accurate, complex sentences that used the word correctly, but as a different word class. Some examiners would subsequently ask for another sentence, but not all. This may have caused more advanced children to look as though they were able to produce fewer sentences. That is, if a child had sufficient knowledge of a word to use it as a less-common word class (e.g.: using “farm” as a verb), this may result in the sentence not being included even though the child has sufficient knowledge of the word. That said, all groups, save the younger LM group, demonstrated similar rates of “wrong word class” responses, hence, any underestimation of abilities should be roughly equivalent across groups.

A second limitation is the nature of the Sentence Complexity Index (SCI). This scale was used in earlier research with narrative and expository language, both written and spoken. These language samples were broken in to T-units, while we used prosodic and situational cues to determine when each sentence ends. Although we added codes to quantify structures not included in the SCI, we were still generally coding much longer utterances than those the SCI was conceived to analyze.

Also, the SCI was not designed to handle responses that might encompass fragments, “I don’t know” responses, or no response at all. We added codes in order to cope with these limitations. However, the basic building block of a T-unit is the simple clause, thus a main-clause verb was scored as zero points since every unit of analysis would have one of these. In our analysis, children had the option of an “I don’t know” response, and we also included sentence fragments that included the target word and a verb. Since the lowest value of zero

points was assigned to a main clause verb, there was no room to make a lower point score for sentence fragments, thus these were scored as being main-clause verbs, as well.

Furthermore, because a single-clause sentence was worth zero points but counted in the number of included sentences, and all syntactic complexity measures were taken over total sentences, it was possible that a child with several single-clause sentences would look worse in terms of SCI points than a child who just kept responding with “I don’t know.” Intuitively, however, we would assume that the latter child has a poorer grasp of the semantics and syntax required for the task.

Finally, this study did not investigate syntactic or semantic errors. Errors were rare and varied and, when we attempted to classify them, reliability was poor (hence errors are not reported here). Existing error classification schemes focused on developmentally early errors and did not take into account the later errors that our subjects could – and did – make in their complex sentences. Rather than attempting to invent an error classification scheme that encompassed errors ranging from early errors such as omission of grammatical morphemes (e.g.: “Scoobydoo they have mystery to solve”) to higher-level argument structure errors (e.g.: “his dog had loyalty to his owner by not running away”), we chose to leave analysis of errors to future researchers who may want to investigate this area.

DISCUSSION

Group Variables

This study adds to the body of research supporting a double-deficit model, which posits that children with ASD plus structural language impairment seem to have SLI "on top of" an autism spectrum disorder. We found that both language-impaired groups built sentences with lower clause and point density values than their age-mates. Our findings agree with several studies which found that children with ASD plus structural language impairment show similar language profiles to children with SLI at young ages and in conversational or narrative tasks. Our data demonstrate that these similarities remain in the later school years and in tasks that are valid in the academic environment.

In children with ASD plus concomitant structural language impairment, we encounter children who have difficulty with both language use and language structure. In our study, children in the SLI group had scores on social communication measures that were slightly worse than, though not significantly different from, their age-peers. Thus, one could make the case that sentence complexity data from these two subject groups may be impacted by a pragmatic impairment.

However, data for both groups not only matched each other but also the younger group of language mates. The language mates do not show evidence of a pragmatic impairment, but do display less developed syntax, as would be expected for their age. Similar scores for all low-syntax groups regardless of diagnostic category strongly suggests that the perceived deficit is a syntactic one.

This study also supports studies that find a range of structural language proficiency in children with autism, broadly defined (e.g.: Kjelgaard & Tager-Flusberg, 2001), including a subgroup of children who have pragmatic impairments as defined by their autism diagnosis but who show no structural language impairment. Even when their semantic and syntactic abilities were taxed by a difficult task, these children consistently performed similarly to their

age-mates. Although they appear free of structural language impairment in this task, note that the task is highly decontextualized. There is no guarantee that the ASD group would fare as well with sentence building in more pragmatically demanding contexts.

One area where all disorder groups were similar to each other was the number of sentences in each child's corpus and reasons for not producing sentences: all groups save the language mates produced similar numbers of acceptable sentences and had similar proportions of "no response" and "wrong word class" entries (the two reasons for not having an acceptable sentence). Language mates had a much higher proportion of "no response" entries (67%) compared to the other groups (30-40%). While we might not expect disorder groups to look similar to their age-mates on this measure, these results have a straightforward explanation: on such a simple level as creating sentences or responding with "I don't know," maturity level is the only variable that impacts performance. To phrase this differently, in older school-age children, diagnosis does not impact simple measures of language ability such as generating a sentence with a target word.

A second, simple measure of language ability that this study investigated is mean length of utterance (in morphemes), or MLU. Our results support studies that find MLU does not discriminate well between disorder groups at this age (e.g.: Klee & Fitzgerald, 1985; Scarborough, Wickhoff, & Davidson, 1986): no effect of diagnostic group was found for MLU. However, an interaction between word class and frequency was found, indicating that high-frequency verbs had the lowest MLU. These findings conflict with our findings for clauses per sentence, which is arguably a more direct measure of syntactic complexity. Since we know that verbs have more complex argument structure requirements than nouns (to be discussed in more detail later), it is possible that the mental effort of producing the required number of clauses would result in a shorter sentence in terms of morphemes – no "extra" words are used. However, since these verbs still require a more complex sentence overall, it would seem that the best explanation is the simplest: MLU is not a valid measure of syntactic complexity in this age group. Not only does MLU not vary by diagnostic group, but it

appears to vary in ways that do not truly indicate changes in sentence complexity.

Word Variables

We now turn to syntactic complexity as it relates to word variables. We investigated word frequency, meaning, and class, hypothesizing that children would create less complex sentences with low-frequency words, abstract words, and verbs. Our results did not support any of these hypotheses: word frequency had a negligible impact on sentence complexity, and children actually made *more* complex sentences with abstract words and verbs.

Word Frequency. Why didn't our subjects show a difference between high- and low-frequency words when previous studies showed frequency effects for areas as varied as word definition, word recall, and verb inflection (e.g.: Mainela-Arnold & Evans, 2005; Marchman, Wulfeck, & Ellis Weismer, 1999; Marinellie & Chan, 2006; Marinellie & Johnson, 2003; Norbury, Bishop, & Briscoe, 2001)? It stands to reason that, since our study investigates older school-age children, our subjects may have had sufficient exposure to language that frequency no longer impacts their performance; that is, these children have had sufficient language exposure that even infrequent words are well-known. However, previous research investigated children of similar ages to our subjects and still found frequency effects.

More telling than age of subjects is the nature of the task. Psycholinguistic theory posits that since low-frequency words are used less often, the neural pathways required for their activation are less strong: low-frequency words are poorly represented neurologically in both strength and number of connections. If the neural representations of these words are more difficult to activate, these words are more difficult to access. Further, related words are more difficult to access since low-frequency words are linked to fewer related concepts.

In our task, subjects did not have to activate these words, they were provided in the stimulus; nor did they have to activate related words as in the defining task, they simply had to create a sentence using the already-activated word. Thus, while a frequency effect was predicted by previous literature, it is not surprising that frequency did not impact the

complexity of sentences produced given our task.

Word Meaning. Contrary to our hypotheses, subjects tended to produce more clauses and more sophisticated clause structures in sentences built around abstract than concrete words. This disagrees with literature that suggests that abstract words are more difficult to acquire and use (e.g.: Gillette, Gleitman, Gleitman, & Lederer, 1999; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell; 2005). Moreover, this contradicts McGregor et al. (in preparation) who used the same cohort of children and the same words in a definition task and found poorer performance on abstract words. One factor that cannot be overlooked is the nature of the task. The definition task may well be more metalinguistically demanding as one cannot depend upon rote phrases as might be possible in the sentence production task (e.g., Decide: We should decide what to eat for dinner; Complain: Don't complain when you don't get what you want). Moreover, defining abstract words taxes knowledge of the advanced concepts underlying that word whereas using it in a sentence taxes knowledge of argument structure more heavily.

Previous research has shown that abstract verbs in particular require very specific argument structures and sentence architecture (e.g: Owen & Leonard, 2006). Our results support this, as the highest clauses per sentence were used with abstract verbs (see Appendix B for a word list). The reader will notice that these words represent ideas that require more complex syntax in order to express: their arguments are more frequently noun clauses or other events and states of mind that require still more complex syntax to describe. Thus, while abstract words may be more difficult to acquire they also elicit more complex syntax when used in a sentence. Creating a sentence with these words is likely an easier task than defining them.

Word class. All groups produced more sophisticated sentences in response to verbs compared to nouns, and the normally developing age-mates produced more total clauses in sentences built around target verbs. This was, of course, opposite of our prediction that nouns would elicit better performance. Again we note that a combination of required argument

structure and required syntax likely yielded more complex sentences for verbs.

Group and Word Variables

Our final prediction was that children with language impairment would have a wider gap than their age-mates between low- and high-frequency words, abstract and concrete words, and verbs and nouns. Because no gaps were found for frequency and gaps that were found were in the opposite direction (abstract better than concrete, verbs better than nouns) this prediction becomes largely moot.

It is interesting to note, however, that only the normally developing age mates produced significantly more clauses in sentences built around verbs than nouns. The fact that the language impaired groups and the language mates did not show greater complexity for verbs may indicate that these groups were unable to construct the complex argument structures required for verbs. However, the fact that the ASD group also did not show a syntactic "benefit" for verbs, when this group was matched to the age-mates on all other measures of complexity, indicates that the difference may not reflect syntactic ability, but perhaps a more semantically-based understanding of what verbs are and how they should be used. Further research on the interaction of diagnostic group and word variables would help illuminate these results.

In summary, this research shows that complex interactions of word factors can result in performance differences within and between diagnostic groups, with the most consistent effect being more complex sentences for abstract than concrete words. Further, the diagnostic groups in this study interact in ways predicted by earlier research: children with autism and structural language impairment create sentences of similar complexity to children with specific language impairment. Children with autism without concomitant structural language impairment create sentences of similar complexity to their age-mates, though pragmatic deficits could render sentence productions more problematic in naturalistic contexts.

IMPLICATIONS

This study offered new insight into the complex syntax of older school-age children with language impairment and autism spectrum disorder. We investigated the areas of overlap between these diagnostic groups and how different word factors impact performance, which has implications for clinical practice and for further research.

Older children with SLI struggle with language even after they start producing complex syntax. Therapy should not end because these children are now able to use embedded clauses: this group still lags behind their peers in their proficiency with complex syntax. For the same reason, researchers should continue to investigate the use of syntax in this group as these children age.

When children with ASD+LI use complex syntax, they look similar to autism with SLI "on top," but can display a wide variation in syntactic ability as a result of pragmatic and structural language deficits. Our data suggests that since these two groups continue show similar language profiles as they age, therapy focused on structural language for children with ASD+LI should continue into the later school years, as it does for children with SLI. Future research focusing on these children's use of complex syntax in a variety of situations would aid in understanding their linguistic profile.

Children show greater proficiency with complex syntax when using verbs and abstract words, which may be related to necessary argument structure for these words. It is notable that children with language impairment, regardless of ASD diagnosis, rose to meet these argument structure demands. Word frequency does not appear to impact complex syntax in children of this age in a sentence generation task. The interaction of word variables and task requires more clinical and research exploration.

APPENDIX A
SUBJECT DEMOGRAPHIC DATA

Table A1: Demographic and test data expressed as group means (and standard deviations)

Construct	*Measure*	*SLI*	*ASDLI*	*ASD*	*LM*	*AM*
Maturation/ experience	age in months	127.64 (19.35)	131.75 (28.91)	132.45 (26.04)	89.65 (25.86)	127.68 (22.88)
Syntax	CELF4 raw score[1]	77.71 (10.20)	75.50 (11.02)	118 (18.62)	78.96 (7.49)	124.65 (5.35)
Social Cognition	SCQ raw score[2]	6.14 (2.38)	15.83 (11.00)	19.90 (8.06)	3.08 (3.07)	3.12 (2.75)
Nonverbal Cognition	KBIT2 matrices standard score	103 (10.00)	101 (12.07)	111 (10.27)	98 (21.15)	112 (10.55)
Socioeconomic status	maternal education in years	14.93 (1.69)	15.67 (2.84)	16.65 (3.17)	15.73 (2.03)	15.63 (1.93)
Working memory	CELF4 WM standard score	83 (12.55)	93 (18.86)	103 (12.94)	108 (11.13)	110 (14.64)
Receptive language	CELF4 Receptive standard score	86 (12.32)	83 (9.89)	110 (11.55)	113 (10.48)	114 (10.46)
Expressive language	CELF4 Expressive standard score	75 (10.89)	69 (13.05)	107 (11.35)	108 (9.6)	115 (8.18)
Receptive Vocabulary	PPVT-III standard score	94 (8.84)	93 (9.80)	116 (13.39)	117 (10.11)	118 (9.12)
Expressive Vocabulary	EVT standard score	74 (13.65)	82 (11.94)	108 (17.98)	105 (10.30)	110 (11.19)

[1]Raw scores on the Formulated Sentences and Recalling Sentences subtests of the CELF4 were summed to derive an estimate of syntactic ability

[2]Raw scores higher than 11 are indicative of autism spectrum disorders (Corsello, Lord, Hus, & Qiu, 2005).

Table A2: *p* values for all t-test comparisons of demographic and test data

Construct	*Measure*	*SLI vs. ASDLI*	*SLI vs. ASD*	*SLI vs. LM*	*SLI vs. AM*
Maturation/ experience	age	0.67	0.63	<0.0001	0.99
Syntax	CELF4	0.77	0.02	0.82	<0.0001
Social Cognition	SCQ	<0.0001	<0.0001	0.002	0.0004
Nonverbal Cognition	KBIT2 matrices	0.61	0.03	0.40	0.007
Socioeconomic status	maternal ed	0.42	0.05	0.22	0.22
Working memory	CELF4 WM	0.13	<0.0001	<0.0001	<0.0001
Receptive language	CELF4 Receptive	0.51	<0.0001	<0.0001	<0.0001
Expressive language	CELF4 Expressive	0.20	<0.0001	<0.0001	<0.0001
Receptive Vocabulary	PPVT-III	0.78	<0.0001	<0.0001	<0.0001
Expressive Vocabulary	EVT	0.13	<0.0001	<0.0001	<0.0001
			ASDLI vs. ASD	*ASDLI vs. LM*	*ASDLI vs. AM*
Maturation /experience	age		.98	<0.0001	0.60
Syntax	CELF4		0.02	0.53	<0.0001
Social Cognition	SCQ		0.06	<0.0001	<0.0001
Nonverbal Cognition	KBIT2 matrices		0.01	0.66	0.002
Socioeconomic status	maternal ed		.31	0.94	0.95
Working memory	CELF4 WM		0.05	<0.0001	<0.0001
Receptive language	CELF4 Receptive		<0.0001	<0.0001	<0.0001
Expressive language	CELF4 Expressive		<0.0001	<0.0001	<0.0001
Receptive Vocabulary	PPVT-III		<0.0001	<0.0001	<0.0001
Expressive Vocabulary	EVT		<0.0001	<0.0001	<0.0001
					ASD vs. AM
Maturation/experience	age				0.52
Syntax	CELF4				0.30
Social Cognition	SCQ				<0.0001
Nonverbal Cognition	KBIT2 matrices				0.75
Socioeconomic status	maternal ed				0.06
Working memory	CELF4 WM				0.10
Receptive language	CELF4 Receptive				0.27
Expressive language	CELF4 Expressive				0.004
Receptive Vocabulary	PPVT-III				0.78
Expressive Vocabulary	EVT				0.72

APPENDIX B
LIST OF STIMULI

Table B1: Full stimuli list sorted by word class, frequency, and meaning

	Nouns		**Verbs**	
	abstract	*concrete*	*abstract*	*concrete*
High-Frequency	chair	energy	draw	believe
	farm	fact	eat	consider
	machine	health	push	decide
	table	law	stretch	enjoy
	river	purpose	walk	love
Low-Frequency	carrot	emergency	fasten	advise
	coin	loyalty	pronounce	complain
	garage	mystery	shove	persuade
	helmet	origin	soak	suspect
	magnet	terror	squeeze	worship

APPENDIX C
TASK INSTRUCTIONS

Instructions for the Sentence Creation Task (spoken to child by examiner):

I'm going to say a word and your job is to put in a sentence. Like if I said "dog" you might say, "The spotted dog hunted cats in the neighborhood," or if I said "memorize" you could say, "The student memorized the answers on the test." Do you have the idea of what to do? OK, the first word is…

Examiner's Note: Prompt for the child to think of a different type of the word if they respond to the wrong word class.

APPENDIX D
COMPLEX SYNTAX CODING KEY

Table D1: Complex syntax coding key, sentence complexity index

Multiword verbs	Insert verb code after the lexical verb, e.g., *he held [v] up the man.*
Use of direct quote codes	Use Q codes only for obviously direct quotes; if indirect – most of these would be coded as complement clauses
Gerunds	Code gerunds that are objects as instances of non-finite complement clauses. If a gerund is used as a subject (e.g., *Running is cool)*, don't code
Catenatives	Gonna, going to, wanna, want to, have to, hafta, went to (go): Treat these as verb complements [v1VCNF]
let me/let's	Codes these as instances of verb complements (*let* is the main verb)
Comment clauses	We decided not to code comment clauses like *that's all*, or *you know*. We <u>will</u> code true tags (e.g., *isn't it*).
Subject complements	Almost all complement clauses function as objects in the main clause (or as complements of adjectives in the main clause), but every once in a while, one is the subject of the main clause, e.g., *But what was more important* was they saved something else, their history. We don't have a separate code for these subject complement clauses, so code as [v1VC], and note it was a subject by using braces ({as subject})
Colloquial passives	Handle these as follows: And after that we *got blew[v] out* and lost[vC] the championship game by 32 points.

Code	Pts	Code Name	Example
[v]	0	Main clause verb	My big brother was[v] cold.
[vLB]	.5	Main clause verb, left-branching	Along came his friend.
[v1T]	1	Level 1 tag [1]	
[v2T]	2	Level 2+ tag	
[v1A]	1	Level 1 adverbial clause	Then I went[v] in the house *because I was[v1A] cold.* Juan was[v] in the lead and turned around[vC*] because he heard[v1A] something.*
[v1AL]	2	Level 1 adverbial clause, late-developing conjunction or nonfinite verb[2]	I was[v] very upset *even though Bandit was[v1AL] not a good cat.*
[v1ALB]	2	Level 1 adverbial clause, left-branching	Then one day *when he was flying[v1ALB*] plop he fell[v].
[v1ALLB]	3	Level 1 adverbial clause, late-developing conjunction, left-branching	*Although they only searched[v1ALLB] for 15 minutes* they found[v] Julia's car. (late-developing conjunction) *Hoping[v1ALLB] they'd find[v2VC] her there*, they knocked[v] on the door. (nonfinite verb, i.e., hoping)
[v2A]	2	Level 2+ adverbial clause	George and Gena fled[v] from the steps to the car and back home where they called[v1AL] the police *to investigate[v2A] the house.*
[v2AL]	3	Level 2+ adverbial clause, late- developing conjunction or nonfinite verb	
[v2ALB]	3	Level 2+ adverbial clause, left-branching	

Table D1: continued

[v2ALLB]	4	Level 2+ adverbial clause, late- developing conjunction or nonfinite verb, left-branching	
[v1R]	2	Level 1 relative clause	And I can't wait[v] for the cruise *your brother planned[v1R] for us*. It was[v] the officer *they called[v1R]earlier*.
[v1RCE]	3	Level 1 relative clause, center-embedded	The reason *I am writing[v1RCE] about summer* is[v] because my birthday is[v1VC] in the summer. Note: Code center embedded relatives relative to the domain of the clause they occur in. For example, in the following example, the relative clause expands on a noun which is itself an object, so is NOT an instance of CE: then when I saw[v1ALB] the *note they left[v2R]* me I got[v] really scared not scared but weird scared.
[v2R]	3	Level 2+ relative clause	
[v2RCE]	4	Level 2 + relative clause, center-embedded	The officer replied[v] by saying[v1AL] *the man who killed[V2RCE]your daughter admitted[v2VC] that he was just getting[V2VC] a ride home.*
[v1PM]	2	Level 1 post modifying clause (other than relative clause)	Once upon a time there was[v] a boy *named[v1PM] Tim*. When the students left[v1ALB] some people in the 6th grade made[v] a plan *to make[v1PM] a mural on the school hallway wall.* They found[v] the hamster in the closet *sitting{v1PM] on the floor* chewing[v1C]
[v2PM]	3	Level 2+ post modifying clause (other than relative clause)	
[v1VC]	1	Level 1 verb complement clause	When they finally got[v1ALB] outside they saw[v] *that John was[v1VC] still inside*..
[v2VC]	2	Level 2+ verb complement clause	So Tim he was following[v] Montana because people were saying[v1A] *that Montana was infected[v2VC] by strange creepy ways.*
[v1VCNF]	0.5	Level 1 verb complement, same subject infinite or other nonfinite form	They always tried[v] *to scratch[v1VCNF] me up* and poke[v1C] my eyeballs.
[v2VCNF]	1	Level 2+ verb complement, same subject infinite or other nonfinite form	
[v1VCNF2]	1	Level 1 verb complement, different subject infinitive or other nonfinite form	He asked[v] *her to come[v1VC] inside for coffee.*
[v2VCNF2]	2	Level 2+ verb complement, different subject infinitive or other nonfinite form	
[v1VQ]	1	Level 1 verb complement, direct quote	Sir he said[v] *I can't fly[v1VQ] anymore*.
[v1VQLB]	2	Level 1 verb complement, direct quote, left-branching	*I can't fly[v1VQLB] anymore* he said[v].
[v2VQ]	2	Level 2+ verb complement, direct quote	And then my cousin came [v] and said [vC] *open[v2VQ] your eyes*

Table D1: continued

[v2VQLB]	3	Level 2+ verb complement, direct quote, left-branching	
[vC]	1	Coordinated clause[3]	Wesley and Cody found[v] a way out *and tripped[vC] the man*.
[v1C]	2	Level 1 coordinated clause	They always tried[v] to scratch[v1VCNF] me up *and poke[v1C] my eyeballs*.
[v2C]	3	Level 2+ coordinated clause	
[v1S]	2	Level1 clause-as-subject	*What makes[v1S] me laugh [v2VCNF2]* is[v] thinking[v1VCNF] about when I pulled[V2VC] Bandit's tail.

[1] Correct or incorrect ordering of verb

[2] Late-developing subordinate conjunction = any conjunction other than *when, so (that), because, (in order) to*

[3] The co-referential subject in the coordinated clause is deleted. (Coordinate conjunctions include *and, but, or*)

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