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Automated Identification of Adverbial Clauses in Child Language Samples

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AUTOMATED IDENTIFICATION OF ADVERBIAL CLAUSES

IN CHILD LANGUAGE SAMPLES

by

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ABSTRACT

AUTOMATED IDENTIFICATION OF ADVERBIAL CLAUSES
IN CHILD LANGUAGE SAMPLES

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In recent years, computer software has been used to assist in the analysis of clinical language samples. However, this software has been unable to accurately identify complex syntactic structures such as adverbial clauses. Complex structures, including the adverbial clause, are of interest in child language due to differences in the development of this structure between children with and without language impairment. The present study investigated the accuracy of new software, called Cx, in identifying adverbial clauses. Two separate collections of language samples were used. One collection included 10 children with language impairment, 10 age-matched peers, and 10 language-matched peers. A second collection contained language from 174 students in first grade, third grade, fifth grade, and junior college. There was high total agreement between computerized and manual analysis with an overall Kappa level of .895.

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Introduction

The development of the capacity to understand and produce complex sentences of various kinds is one of the most significant and remarkable aspects of language acquisition. As a child begins to convey complex ideas, utterances containing multiple verbs are used to communicate abstract and sophisticated messages for which syntactically simple expressions may be inadequate (Limber, 1971). One clausal element used to accomplish this linguistic expansion is the adverbial clause. According to Wells (1985), the median age of emergence of adverbial clauses is 3½ years. Children begin by using single word adverbials, such as *I saw the movie **yesterday***. They progress to prepositional phrase adverbials, for instance, *I saw the movie **on Friday***, and finally to adverbial clauses, as in the sentence *I saw the movie **before I ate lunch***.

Adverbials are a significant part of a child's language, adding depth and variety while allowing the child to use language to describe elements such as location, time, reason, and manner. Through the use of adverbial clauses, children can express those relationships with even more detail while defining cause and effect relationships that exist in language, building more meaningful conversations. For example, in the sentence *Sally kissed Jim **after Jim fainted***, the adverbial clause allows the speaker to more clearly identify the nature of the occurrence. The listener understands whether Jim fainted *because*, *before*, or *after* Sally kissed him, rather than simply knowing that the two events both occurred.

While the acquisition of complex syntax appears to be effortless for many children, it is well established that children with language impairment (LI) demonstrate difficulty understanding and producing complex sentences (Scott, 1988). Children with language impairment use fewer adverbial clauses than children with typical language

(Marinellie, 2004). In addition to less frequent use, adverbial clauses produced by children with language impairment may be simple or grammatically inaccurate (Diessel, 2004). Mean Length of Utterance (MLU) is lower in children with LI due to, among other things, the simplicity of their language. Such limitations in production can be used as clinical markers in identifying possible impairment of language.

A child's language complexity, including the use of adverbials, is often assessed in clinical settings. Complex structures like adverbial clauses do not show up frequently in conversational child language samples, but when they do, they provide valuable information about a child's level of language functioning. Because children with impaired language use less elaborative language containing fewer adverbial clauses, it is crucial to know which children are producing these structures. However, many clinicians do not carry out an organized analysis on language samples they collect because of the complexity and time involved in performing a language sample analysis by hand. Reliable software would allow a clinician to look at a child's abilities without having to spend valuable time analyzing or rechecking sentences.

Over the last 20 years, researchers have developed software programs for language sample analysis. Many programs are available, such as *Child Language Analysis* (CLAN; MacWhinney, 2006), *Computerized Profiling* (CP; Long, Fey, & Channell, 2000), *Parrot Easy Language Sample* Analysis (PELSA, Weiner, 1986), and *Systematic Analysis of Language Transcripts* software (SALT; Miller & Chapman, 2004). Of these, only CP attempts to analyze complex syntax, but its accuracy is poor (Long & Channell, 2001). A software program capable of accurately locating adverbial clauses would be a useful clinical tool as it would allow clinicians to describe complex language structure more efficiently. Recently, Cx, a new software program has been developed that uses probabilistic methods to identify finite adverbial clauses (Channell, 2008). However, this program has yet to be empirically investigated.

The purpose of the present study is to investigate the accuracy of the Cx software in identifying adverbial clauses.

Review of Literature

This review will focus on the development of adverbials in children and on software for the analysis of children's syntax, including adverbials.

Adverbials

In general, an adverbial is a word or group of words that modifies or describes a verb and increases the explicitness of the actions described in the sentence (Greenhalgh & Strong, 2001). Adverbials add additional information about the time, place, reason, or manner of events and can be adverbs, adverbial phrases, or adverbial clauses (Jacobus & Miller, 1976). According to Crystal (2004), adverbials can be divided into four main classes, including *adjuncts*, *subjuncts*, *conjuncts*, and *disjuncts*. Adjuncts indicate the circumstances of the action and answer questions like *when*, *where*, *how*, and *why*. Conjuncts bind together sentences and express relations between them. Disjuncts express a speaker’s evaluation or judgment of the style or content of the sentence, and subjuncts express viewpoints or mark focus in a sentence.

Adverbs. An adverb is traditionally defined as a single word that describes when, where, why, or how. There are adverbs of time, manner, degree, location, direction, and transition (Quirk, Greenbaum, Leech, & Svartvik, 1985). Manner adverbs, which typically end in –*ly*, are generally the easiest to recognize. In the sentence *He ran* ***quickly***, the adverb *quickly* describes the manner in which the subject ran. In addition to modifying verbs, adverbs can also modify adjectives or other adverbs, such as the words *very* or *quite*. Many adverbs change the meaning of a sentence when they are placed in alternate positions in the sentence (Conlon & Evens, 1992). For instance, the sentence ***Cleverly****, he answered the question* may have a different meaning than the sentence *He* ***cleverly*** *answered the question*.

Adverbial prepositional phrases. In general, moveable phrases that begin with prepositions and modify verbs are adverbial phrases (Jacobus, 1976). The entire phrase functions as an adverb as in the sentence *He ran* ***on Saturday***. Words like *as*, *in*, *on*, *at*, *before*, and *after* are prepositions when they introduce a phrase, as in the sentence *The children washed their hands* ***before dinner***. However, when these words introduce clauses, like adverbial clauses, they are considered subordinating conjunctions, as in the sentence *The children washed their hands* ***before they ate dinner*** (Verspoor & Sauter, 2000).

Overview of Adverbial Clauses. Groups of words that modify a verb can also be adverbial clauses. In an adverbial clause, the entire clause functions as an adverb (Hartmann & Stork, 1972). A clause is different from a phrase, however, in that it contains a subject, which defines who or what is completing the action, and a predicate, which always contains a verb (Mitamura & Nyberg, 1995). For example, in the sentence He ran on Saturday because he had a track meet, the subject of the adverbial clause is he and the predicate is had a track meet. The subject in an adverbial clause can either be explicit, as in the sentence I saw Joe when I went to the store, or implied as in He sat quietly in order to appear polite. Consider the sentences We went shopping yesterday, We went shopping after lunch, and We went shopping while it was raining. While all three sentences answer the question when, only the adverbial in the final sentence containing the adverbial clause has a subject, it, and a full verb, was raining. However, the adverbial clause, like the adverb and adverbial phrase, is dependent on the main clause and lacks illocutionary force (Haiman & Thompson, 1984).

Like adverbial prepositional phrases, most adverbial clauses can be recognized by the word or phrase that precedes them, such as *when* or *so that*. These words or phrases, called subordinating conjunctions, come in numerous forms, including *after, before*, *until*, *while*, *because*, *since*, *as*, *like*, *in order*, *if*, *unless*, *whether*, *though*, and w*here* (Diessel, 2001). According to Chafe (1984), the most commonly used forms of adverbial clause subordination in conversation are achieved through the words *if*, *because*, *when*, *whenever*, *before,* and *after*.

Adverbial clauses typically occur in the initial or final position of sentences (Diessel, 2001). These appear in both finite and non-finite forms. A finite adverbial clause is one in which the verb phrase has tense, such as *They ate dinner* ***after they watched a movie***. The verb *watched* indicates that the event took place in the past. Finite forms of adverbial clauses are easier to recognize and include subordinating conjunctions which indicate time, place, reason, result, manner, condition, and concession (Scott, 1988). These are the first forms to appear when children begin using adverbial clauses.

Non-finite adverbial clauses rarely contain subordinating conjunctions and are more difficult to recognize and interpret. Non-finite adverbial clauses, in which the verb phrases do not have tense, can be infinitives or past or present participle phrases (Verspoor & Sauter, 2000). Infinitives can function as adverbials of reason, as in the sentence, *She searched the house* ***to find her mother***. The non-finite adverbial clause can be recognized in this case because it can be placed in alternate positions in the sentence and still makes sense after adding the words *in order* just prior to the clause.

Participle clauses have two forms, including those with *–ing* participles, or present participle forms, as exemplified in the sentence ***Drinking apple juice***, *the girl began to choke*, and those with *–ed* participles, or past participle forms, as in the sentence ***Tired from running***, *she rested beside a tree* (Huddleston, 1984). A gerund, which is used in the sentence ***Drinking apple juice*** *is fun*, is often confused with present participle phrases. Non-adverbial infinitives, as in the sentence *She turns her head and refuses* ***to look***, may also be confused with infinitives functioning as adverbials of reason.

Development of Adverbials

Adverbs are initially observed in a child's language at about 2;0 (years;months). Typically, children first use adverbs relating to contrast, for instance, *already* and *still*, followed by those indicating time such as *yesterday* and *tomorrow* (Weist & Buczowska, 1987). In general, by 3;0, children can use a variety of prepositional phrase adverbials such as *in five minutes* (Weist, 2002). The development of adverbial clauses progresses from using single word adverbials to prepositional phrase adverbials and finally adverbial clauses.

Adverbial clauses are an important part of English discourse and appear in a child's language as complex sentences begin to develop. According to Limber (1971), many studies on early syntactic development show that most children have the ability to generate complex constructions before their third birthday. While watching his 35 month old daughter learn language, Leopold (1939-1949) stated, "…with the mastery of complex sentences, the linguistic development has reached the last stage" (Vol. 4, p. 37). A variety of adverbial conjunctions come into frequent use throughout the second half of the third year, most commonly in the form of *so, if, because*, and *when* with periodic use of *before* and *after*. Children use these subordinators to form adverbial clauses (Diessel, 2004).

In learning to use complex language that includes adverbial clauses, children first use simple sentences containing an adverb followed by those containing a single preposition and no embedding. However, while complex forms such as complement and relative clauses develop through expansion of an utterance, adverbial clauses evolve by integrating two grammatically independent simple sentences (Diessel, 2004). For example, two separate sentences such as *This tastes good* and *It has sugar on it* become *This tastes good because it has sugar on it*. Children learn to comprehend temporal, causal and conditional relationships before indicating them in conjunctions (Eisenberg, 1980). As this cognitive development takes place, they begin to use adverbial clauses to express these relationships.

Age of emergence. Many experimental and observational studies have been performed in attempts to learn more about the acquisition of adverbial clauses (Diessel, 2004). However, these two types of studies differ greatly in their findings. According to the experimental studies, many children six-, seven-, and even eight-years old do not fully comprehend certain types of adverbial clauses. In contrast, the observational studies suggest that children as young as 3;0 use a wide variety of adverbial clauses appropriately. According to Wells (1985), the median age of emergence is 3;5. Tyack and Gottsleben (1986) argue that such clauses are not typically produced until MLU reaches 4.0. According to O’Grady (1997), development of adverbial clauses continues until after 6;0. Finite adverbial clauses are generally the first forms to appear, followed by non-finite forms which may not be used for several years after finite forms have been established. Fletcher and Garman (1986) found that finite adverbial clauses occur more frequently in speech than writing until age 10;0 while non-finite forms, which occur less often than finite adverbial clauses, are more common in writing than speech.

Common forms and order of acquisition. The forms *when*, *because*, *if*, and *in order to* are the main forms of adverbial clauses used throughout the school years in conversation and narrative discourse (Scott, 1987). Tyack and Gottsleben (1986) noted that the first forms to appear are usually *because* and *when*, which represent reason and time relations, making up over three-fourths of preschool children's usage of adverbial clauses. Months later, additional clauses begin to appear, including the forms *before* and *after*. For example, the sentence ***After I get finished with it***, *I'm gonna play it back* was produced by a typically developing child age 3;4 (Scott, 1988). Bowerman (1979), however, noted that the subordinating conjunctions *before* and *after* are infrequent at age 5;0. Condition and result relations also begin to appear with increasing frequency, such as the forms *if* and *so*, while place, manner, and concession appear less frequently in the language of primary school children (Scott, 1988). Children rapidly learn to use a limited set of adverbial clauses, but development reaches a ceiling in early school years. Development continues as children expand the range of meaning of the same conjunctions, increase clause order and flexibility, and use nonfinite forms of adverbial clauses, which are more common in written than spoken language (Scott, 1987).

Factors Influencing the Development of Adverbial Clauses

Two factors, aside from general cognitive intelligence, are known to influence a child's development of adverbial clauses; these factors are frequency and sentence position.

Frequency in ambient language. The frequency of adverbial clause use in ambient language influences adverbial clause development. When mothers use adverbial clauses more often, they appear earlier in the child's speech (Diessel, 2004). Table 1 shows the mean proportions of the most frequently used adverbial clauses in a mothers' speech and the mean age of appearance of each adverbial clause in the child's language. The adverbial clauses that were used more frequently by the mother were used at an earlier age by the child, showing the influence of ambient language in the acquisition process.

Table 1

Mean Proportions of the Mothers' Conjoined Clauses and the Mean Age of their Appearance in the Child's Data

	Mean proportion in mothers' speech	Age of appearance in child's speech
and	33.5	2;2
when	13.7	2;10
because	13.1	2;5
if	10.8	3;0
but	10.3	2;8
so	8.7	2;7
before	2.2	3;2
after	1.7	3;4
while	1.5	3;2
until	1.2	3;4
since	.2	3;11
other clauses	3.1	

Sentence position of adverbial clauses. Another factor that affects the way adverbial clauses develop in a child's language is the difference in complexity and processing load between initial and final adverbial clauses. Diessel (2004) noted that complex sentences that contain adverbial clauses in the final position are easier to process and are used more often by children than those containing initial adverbial clauses. This is because interpretation of initial adverbial clauses may be impossible before the whole sentence has been processed. For example, consider the sentence, ***After we left****, it began to rain*. The initial adverbial clause is a dependent structure that requires the final clause, which is the matrix clause, to form a complete sentence. The individual processing the sentence must hold the initial clause in working memory until the end of the sentence. Children under 3;0 are unlikely to produce these because their occurrence is tied to complex discourse structures that evolve gradually during the preschool years (Diessel, 2004). In other words, they serve pragmatic functions that are not needed at a young age.

There are only a few initial adverbial clauses typically used by young children; these include *when, if, after, while,* and *since*, such as in the example, ***If he takes all of them****, I'm gonna beat him up* (Diessel, 2004). However, even these clauses are far less common than final adverbial clauses. In transcripts of five children ages 3; to 5;0 collected by Clark (1970), 96.1% of all adverbial clauses produced out of 4,918 total adverbial clauses were final clauses. Initial clauses made up only 2.9% of adverbial clauses while the remaining 1% were unclear. According to Diessel (2001), children are far more likely to use temporal, causal, result, and purpose clauses in the final position of sentences, whereas conditional clauses are more likely in the initial position with 53% occurring at the beginning of sentences.

Adverbial Clauses in Children with Language Impairment

Children with LI demonstrate difficulty understanding and producing complex syntax (Scott, 1988). According to He, Brown, Covington, and Naci (2004), sentence complexity is important in determining the presence of language impairment. Children with LI likely differ from children with typically developing language in the acquisition process of these complex structures, including adverbial clauses, in several ways (Diessel, 2004). There may be a delayed appearance of complex syntactic forms, a less frequent use of complex syntax or a restricted range of forms, and the use of grammatically inaccurate complex syntactic forms.

Kent (2004) agreed that school-aged children with language disorders use conversational speech characterized by shorter and simpler utterances than their peers with typical language. Kent described how children with LI may use multiple short utterances to relay the same content that children with typical language do in one or two complex sentences. The utterances used by children with language impairment may be free of grammatical errors but will likely not contain the complex elements used to connect ideas. This lack of complexity contributes to a low MLU in these children, which can assist in identifying language impairment (Eisenberg, Fersko, & Lundgren, 2001).

Marinellie (2004) also agreed that the language of children with language impairment includes fewer adverbial clauses and other elements of complex language than children with typical language. However, according to Marinellie, children with typically developing language demonstrate a quantity rather than a quality advantage compared to children with LI. Children with language impairment use fewer adverbial clauses but in similar proportions by clause type. Clauses of reason were used most frequently by both groups followed by clauses of time. Results of a study by Moore

(1991) also indicated that children with LI followed normal but delayed developmental patterns.

Godard and Labelle (1999) argued that children with LI have more difficulty mastering temporal adverbials than do children with typically developing language. The authors noted that those adverbials referring to the present are more easily mastered by children with LI than those referring to past or future. Fletcher and Peters (1984) explored which aspects of language production distinguish children diagnosed with language impairment from those with typical language. Fletcher and Peters collected 200 utterance language samples from nine children with LI (mean age of 5;2) and 20 age matched children with typically developing language. Out of 65 grammatical and lexical categories analyzed, the two groups were significantly different in 23 of them, with one of the top ten being adverbial clauses. These results indicate that adverbial clauses are one of the features that help differentiate between children with typical language and those with language impairment.

Language Sample Analysis Software Programs

Several computer software programs are available for transcribing, analyzing, searching and quantifying data from language transcripts.

SALT. SALT (Miller & Chapman, 2004) is a software program developed by John Miller that analyzes language transcripts to calculate a variety of standard measures and compare performance to age-matched peers. Measures include MLU, type-token ratio (TTR), frequency of morphemes, use of morphemes, intelligibility, and others. The user, however, must perform certain parts of the analysis manually for measures to be accurately calculated, including coding verb tenses, missing lexicons, unintelligible utterances, and identifying utterance boundaries. Morphemes must be coded by inserting slash marks between root words and bound morphemes to define morphological boundaries. This information is entered into the computer using specific codes and the computer organizes the data to facilitate interpretation.

The SALT program has several limitations. While the program provides a detailed summary of its measures, it is subject to clinical error, because the analysis depends on the accuracy of the codes as determined by the clinician. Additionally, SALT does not attempt to analyze higher level constituents, such as performing a phrase or clause level analysis.

PELSA. The PELSA software, developed by Frederick Weiner (1986), uses percentages to make comparisons across samples. The software provides the percentages of correct use of demonstratives, locatives, pronouns, prepositions, and other simple grammatical markers. A summary table is presented with information about sentence types, number of utterances, TTR, and MLU. However, according to Baker-Van Den Goorbergh (1994), the calculations were incorrect in nine of ten samples analyzed by the program.

CLAN. The CLAN software (MacWhinney, 2006), initially written by Leonid Spektor and Brian MacWhinney in 1984, is another computer program used to analyze language transcripts. CLAN was developed as a part of the Child Language Data Exchange System (CHILDES) project with a goal of creating a large database of transcripts from a variety of languages to help address research questions in child language studies. CLAN uses language transcripts formatted in a system called *Codes for Human Analysis of Transcripts* (MacWhinney, 1996) to examine a variety of aspects of language through automatic analyses including frequency counts, word searches, cooccurrence analyses, MLU, interactional analyses, text changes, and morphosyntactic analysis. Morphological analysis is performed by the MOR program based on information about English grammar and vocabulary contained in data files. The language sample is then coded for parts of speech using the *POST* program, following which analyses such as DSS can be performed.

The CLAN software has several limitations. For example, the user must manually review the codes generated by the software and correct any errors before final results are tabulated. Similarly, the DSS analysis performed by CLAN is not fully automated; sentence points must be added manually based on grammatical, pragmatic, and semantic accuracy. MacWhinney (2006) discussed limitations of automated DSS analysis using CLAN, including its inability to analyze certain grammatical forms. Like the SALT software, CLAN does not attempt to analyze complex syntax.

CP. The CP software (Long et al., 2000), developed by Steven Long and Marc Fey, analyzes files formatted according to SALT specifications (Miller & Chapman, 2004). The program performs several automated functions including DSS analysis, Language Assessment Remediation Screening Profile (LARSP; Crystal, 1982; Crystal, Garman, & Fletcher, 1989), and the Index of Productive Syntax (IPSyn; Scarborough, 1990). CP describes the grammatical structure of sentences using a file of codes based on LARSP. The clinician is required to edit codes that are incorrectly generated by the program before the program provides a complete LARSP profile (Long & Fey, 1993).

Of the software programs available for clinical analysis of child language samples, only CP attempts to analyze complex syntax. However, research has shown that it performs poorly at this task, with coding of the subclause level in LARSP being only 15% accurate overall (Long & Channell, 2001).

Cx. Cx is a new program developed by Ron Channell (Channell, 2008) which claims to more accurately locate complex structures in child language samples. Using an updated version of the software used in Channell and Johnson (1999), Cx first codes each word in the language sample for grammatical category using probability information. Basically, clauses noted as containing a subordinating adverbial and a verb are identified as being likely to contain an adverbial clause. The utterances likely to contain adverbial clauses (or other complex structures of interest) are listed in a text file.

Conclusion

Adverbial clauses are important developmentally and offer insight into the language abilities of children with LI. To date, however, software has been ineffective in analyzing clinical samples of children's language for adverbial clauses. Thus software which claims to identify utterances containing finite adverbial clauses might be beneficial to clinicians, if shown to be effective. The present study examines the accuracy of recently developed software, called Cx, which makes this claim.

Method

The present study is part of a larger research project to evaluate the Cx software; other studies in the project will evaluate Cx's effectiveness in identifying finite relative clauses and noun clauses.

Participants

Two separate collections of language samples were used in the present study. *Reno samples.* A total of 30 child language samples were collected by Fujiki, Brinton, and Sonnenberg (1990) for a study of conversational repairs. The samples were collected in the Reno, Nevada area. Included in the study were ten children with LI, ten children matched by chronological age (CA), and ten children matched by language age (LA). Each group contained five males and five females. None of the children had a history of hearing, cognitive, neurological, or severe articulation impairment. Children with LI were between the ages of 7;6 and 11;1 and had received language services from a speech-language pathologist since first grade. These children all scored one standard deviation or more below the mean on each of two standardized tests, demonstrating impairments in both comprehension and production. On a measure of nonverbal intelligence, however, they scored within normal limits. The tests given to the children in the LI group included the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981) the Test for Auditory Comprehension of Language-Revised (TACL-R; Carrow-Woolfolk, 1985), subtests taken from the Test of Language Development-Primary (TOLD-P; Newcomer & Hammill, 1997), and the Clinical Evaluation of Language Functions Screening Test (Semel & Wiig, 1980). LA children, who ranged from 5;6 to 8;4 years, were given the Utah Test of Language Development (Mecham, Jex, & Jones, 1967) and matched by a language age score within six months of the impaired child's language performance. CA children (7;6-11;2) were within four months of age and attended the same elementary school as their LI match. Descriptive statistics for the sample are presented in Table 2. With only the child and examiner present, thirty minute spontaneous child language samples ranging from 200 to 400 utterances were collected. The samples were elicited using an assortment of toys and games including view master, a Guess Who game, transformer toys, and a magic kit. Familiar topics such as favorite movies and vacations were also used to stimulate conversation.

Table 2

Descriptive Statistics for the Reno and Los Angeles Samples

Child	Gender	Age	N Utterances	MLU	DSS
LI 1	F	9;3	244	5.18	6.30
LI 2	F	7;6	459	5.67	8.46
LI 3	M	9;3	178	4.36	4.27
LI 4	F	8;8	300	5.23	7.30
LI 5	F	8;8	453	5.64	8.50
LI 6	F	9;5	365	5.66	8.22
LI 7	M	9;11	611	5.94	8.41
LI 8	M	11;1	475	5.39	6.88
LI 9	M	8;8	253	4.73	5.64
LI 10	M	9;1	253	4.03	4.59
LA 1	F	7;7	336	5.61	9.07
LA 2	F	7;4	231	5.62	6.08
LA 3	M	7;11	300	7.18	10.85
LA 4	F	5;6	320	5.38	7.05
LA 5	M	6;10	273	5.70	7.01
LA 6	F	8;4	497	6.20	9.40
LA 7	M	5;9	356	4.76	7.67
LA 8	M	6;5	312	5.00	6.51
LA 9	M	6;11	491	5.00	7.59
LA 10	F	7;0	363	6.43	7.12
CA 1	F	7;6	442	6.32	8.15
CA 2	M	9;0	356	7.28	9.48
CA 3	F	8;10	460	5.63	7.85
CA 4	M	8;4	468	6.79	8.32
CA 5	M	10;2	337	6.34	8.86
CA 6	F	9;2	481	8.04	10.61
CA 7	F	8;10	349	7.26	9.31
CA 8	M	8;8	398	7.01	8.84
CA 9	M	11;2	309	6.64	9.11
CA 10	F	9;2	346	7.34	10.66
FIRST	M/F		2549	7.61	10.43
THIRD	M/F		2689	7.81	10.87
FIFTH	M/F		3525	7.66	11.55
ADULT	M/F		2033	7.83	12.00

Los Angeles samples. These language samples, discussed in Carterette and Jones (1974), were collected for a study of informal speech. A total of 174 individuals from the Los Angeles, California area participated in the study, including 54 first graders, 48 third graders, 48 fifth graders, and 24 adults. Because the younger children were more likely to interrupt, giggle and drown each other out, more participants were needed for the first grade samples to provide a comparable amount of material. Children from the middle socioeconomic level from two different schools participated in the study. All children in each grade being studied were included in the sample except for foreign language speakers, those with speech impediments, and those with non-California dialects. The child samples were collected in a simple social situation with three children sitting around a table, engaging in conversation. An adult prompted the children only when extra encouragement was necessary but otherwise said nothing. The adult samples were taken in a similar community, region, and socioeconomic class as the child samples and participants were enrolled in a psychology class at a junior college. Adults were told they were part of an experiment investigating small group processes, and were also placed in groups of three and told to talk amongst themselves. While many of the children were familiar with each other, most of the adults were not.

Procedure

Manual coding. Transcripts of the child language samples were analyzed and manually coded for adverbial clauses. The Reno samples were previously coded for finite adverbial, relative, and noun clauses by another examiner. Finite forms are those in which the verb phrase has tense, as in the sentence *I didn't call* ***because I was busy***. The Los Angeles samples were coded for finite adverbial clauses by the author. Reliability for manually identifying adverbial clauses was established by having a second observer independently code 25% of the samples. Point-by-point agreement between the two raters was 99% with a Kappa value of .950, $p < .01$.

File formatting. The Los Angeles samples were transformed into SALT formatted files according to published guidelines (Miller & Chapman, 2004). The Reno samples had been previously formatted for automatic analysis in SALT. As Cx only uses information in the SALT-specified coding for *'s*, other morphemes were not coded.

Computer analysis. Both sets of samples were then analyzed by the Cx software (Channell, 2008). The Cx software uses probabilities extracted from other samples to grammatically code structures such as adverbial, relative, and noun clauses. Certain words occurring in particular grammatical contexts are recognized by Cx as possibly indicating adverbial clauses. The software then produces a text file listing the utterances which are likely to contain one or more adverbial clauses.

Data analysis. The results of the overall analysis are described in terms of four possibilities, including true positives, false rejections, correct rejections, and false positives. True positives are the number of utterances agreed upon as containing an adverb clause by both computer and manual analysis. False rejections, or misses, are the utterances which were shown to contain an adverbial clause by manual analysis but not identified by computer analysis. A correct rejection is when neither manual nor computer analysis finds an adverbial clause in an utterance. False positives occur when an utterance is identified as containing an adverbial clause by automated analysis but not by manual analysis. Point-by-point agreement and Kappa levels are calculated using these four possibilities.

Results

The numbers of adverbial clauses identified in the Reno and Los Angeles samples by manual and computer analysis are listed separately in Tables 3 and 4 along with the Kappa values obtained using these numbers.

Table 3

Manual and Computer Identified Adverbial Clauses in the Reno Samples

	Number of Adverbial Clauses		
Group	Manual[a]	Cx[a]	Kappa[b]
LI	126	153	.855
LA	181	210	.856
CA	219	261	.871
Total	520	624	.867

[a] the number of utterances identified as containing one or more adverbial clauses. [b]calculated between Manual and Cx identified adverbial clauses.

Table 4

Manual and Computer Identified Adverbial Clauses in the Los Angeles Samples

	Number of Adverbial Clauses		
Group	Manual[a]	Cx[a]	Kappa[b]
FIRST	262	267	.947
THIRD	229	239	.935
FIFTH	298	318	.897
ADULT	151	183	.844
Total	940	1007	.910

[a] the number of utterances identified as containing one or more adverbial clauses. [b]calculated between Manual and Cx identified adverbial clauses.

In both sets of samples, Cx found more utterances containing adverbial clauses than were found manually. The software was more likely to falsely identify adverbial clauses than to miss them in an utterance.

There was high total agreement between manual and Cx analysis in locating adverbial clauses. Total point-by-point agreement for the 29 separate Reno samples was .987 and total for the four Los Angeles samples was .985 as shown in Table 5, rounded to two decimal places. Analysis of both sets of samples yielded high Kappa values, .867 for the Reno samples and .910 for the Los Angeles samples, signifying high levels of agreement between manual and Cx analysis while controlling for chance agreement. The mean of all the Kappa values was .859 for the Reno samples with a standard deviation of .088 and .906 for the Los Angeles samples with a standard deviation of .047. Total agreement for both sets of samples combined was .986 with an overall Kappa value of .895. Kappa values ranged from .658 to 1.00 for all subgroups included in the study.

Table 5 shows detailed information on the number of true positives, false rejections, correct rejections, and false positives for each sample, including each LI, LA, and CA child, each separate age group from the Los Angeles samples, as well as a total analysis of all samples combined. A high positive correlation between computer and manual coding was obtained for both sets of samples, $r = .972$ for the Reno samples and $r = .966$ for the Los Angeles samples, $p < .01$.

The program's accuracy in identifying adverbial clauses among separate groups was also analyzed. The three Reno groups differed in the number of adverbial clauses present, whether identified manually or using the Cx software. A one way ANACOVA, using sample length as the covariate, found significant differences among groups for

Table 5

Point-by-Point and Kappa by Subject for the Reno and Los Angeles Samples

Sample	a	b	c	d	Point-by-Point	Kappa
LI 1	9	3	0	232	0.99	0.85
LI 2	20	3	1	435	0.99	0.91
LI 3	3	1	0	174	0.99	0.85
LI 4	9	0	1	290	1.00	0.95
LI 5	13	7	1	432	0.98	0.76
LI 6	29	7	1	328	0.98	0.87
LI 7	27	10	1	573	0.98	0.82
LI 8	8	2	1	464	0.99	0.84
LI 9	2	0	0	251	1.00	1.00
LI 10	0	0	0	253	1.00	NC
LA 1	6	5	1	324	0.98	0.66
LA 2	6	1	0	224	1.00	0.92
LA 3	31	8	3	258	0.96	0.83
LA 4	21	4	0	295	0.99	0.91
LA 5	5	1	0	267	1.00	0.91
LA 6	39	3	0	455	0.99	0.96
LA 7	10	6	1	339	0.98	0.73
LA 8	16	5	0	291	0.98	0.86
LA 9	3	2	1	485	0.99	0.66
LA 10	32	6	0	325	0.98	0.91
CA 1	28	1	1	412	1.00	0.96
CA 2	20	2	2	332	0.99	0.90
CA 3	25	10	1	424	0.98	0.81
CA 4	12	7	0	449	0.99	0.77
CA 5	21	14	0	302	0.96	0.73
CA 6	39	7	1	434	0.98	0.90
CA 7	20	3	1	325	0.99	0.90
CA 8	13	3	0	382	0.99	0.89
CA 9	12	1	0	296	1.00	0.96
CA 10	21	2	2	321	0.99	0.91
TOTAL	500	124	20	10372	0.99	0.87
FIRST	252	15	10	2272	0.99	0.95
THIRD	220	19	9	2441	0.99	0.93
FIFTH	279	39	19	3188	0.98	0.90
ADULT	143	40	8	1842	0.98	0.84
TOTAL	894	113	46	9743	0.99	0.91
TOTAL	1394	237	66	20115	0.99	0.89

Note. NC indicates Kappa could not be calculated because data did not meet the required assumptions.
a = agreement on presence of an adverb clause in a c-unit. b = adverb clause identified by Cx but not manual analysis.
c = manually identified adverb clause not found by Cx. d = agreement on the absence of an adverb clause in a c-unit.

manually identified adverbial clauses, $F(2, 26) = 4.28$, $\eta^2 = .331$, $p = .014$, and for Cx-identified adverbial clauses, $F(2, 26) = 4.79$, $\eta^2 = .356$, $p = .009$.

The number of adverbial clauses in the Reno samples was also related to the MLU and the DSS scores which were shown in Table 2, whether identified manually or with the Cx software. Controlling for differences in sample length using partial correlation, the number of manually identified adverbial clauses correlated with MLU, $r = .590$, $p = .001$ and DSS $r = .563$, $p = .001$, and the number of Cx-identified adverbial clauses correlated with MLU $r = .537$, $p = .003$ and DSS $r = .525$, $p = .003$. Of the false positives made by Cx, 50% were wh-noun clauses, 14% were non-clausal adverbials, and 36% were other errors including non-complex structures.

Discussion

Overall, the Cx software identified utterances containing adverbial clauses with a high level of accuracy. This was reflected in the high point-by-point agreement levels, high Kappa values, and by the high level of correlation between the numbers of Cx-identified and manually identified adverbial clauses in samples. Both the frequencies of manually and Cx-identified adverbial clauses reflected group differences in the Reno samples; children in the LI group consistently used the fewest adverbial clauses overall, followed by the LA group and finally the CA group.

The results of the present study are similar to those obtained by Michaelis (2009), who found high levels of agreement between manual coding and Cx's coding when identifying relative clauses, another complex grammatical structure. An overall kappa value of .884 was obtained with significant differences found between the number of relative clauses identified in the LI and CA groups. Michaelis also reported a high correlation between manual and computer analysis, *r* =.990.

In past publications, the accuracy of automated tagging of subordinate clause elements has proven to be poor. Long and Channell (2001) found that the accuracy of the CP software for LARSP's subclause line was only 15%. The current study suggests that Cx's approach to analysis offers potential, but several cautions exist.

Characteristic Errors Made by the Cx Software

Examination of the utterances in which the Cx software inappropriately identified adverbial clauses is helpful to illustrate the program's current limitations. For instance, Cx often incorrectly identified wh-noun clauses as adverbial clauses in sentences such as *No matter where they go, they're not wanted*. In a few instances, wh-noun clauses containing *if* were confused with adverbial clauses, as in the sentence *I don't know if I would like to do it or not*, but otherwise *if* clauses were consistently correctly identified. Cx also occasionally identified adverbial clauses in sentences missing a verb that would otherwise contain an adverbial clause, such as *I saw it one time when this man*. Similarly, adverbials that were not part of a clause were often mistaken as adverbial clauses, as in *After a few hours of that, (oh) we come home*.

The Cx program also did not perform well in differentiating between *like* as a slang part of speech and *like* as a subordinator and part of an adverbial clause. For instance, the computer falsely tagged the sentence *On our test (you know) like we'd have (uh) let's say earn or something* but missed the adverbial clause in *Do your kittens like warm baths like Spooky does?* The Cx program also occasionally missed adverbial clauses beginning with *as*, *once*, *before*, *after*, *even though*, and *until* but consistently correctly identified *because*, *when*, *since*, and *if* clauses. These same trends, including false rejections and false positives made by computer analysis were noted in all of the samples used, including the various age groups from the Los Angeles samples as well as the three separate groups in the Reno samples. Many of the false rejections and false positives made by the program might be attributed to the fact that humans use prosody, world knowledge, and context to determine the proper grammatical analysis of an utterance.

Adverbial clause recognition in Cx is dependent upon a single tag for words used as subordinating adverbials. The appropriateness of this tag is calculated by a more recent version of the program examined in Channell and Johnson (1999). That study showed that the program's accuracy for applying the subordinating adverbial tag was 95%. Thus the accuracy of adverbial clause identification may have been affected by inaccuracy in the coding of the individual word which introduces adverbial clauses, rather than an incorrect decision rule being applied by the Cx program itself.

As shown in the Los Angeles samples, the program’s accuracy decreased as age group increased based on Kappa scores (refer to Table 4). This is common in the field of automated analysis (see Channell & Johnson, 1999 or Long & Channell, 2001) and is likely due to the increased complexity of speech with increased age. The program made fewer mistakes with simpler language, as there were fewer opportunities for error.

Strengths of the Cx Software

Cx did not have difficulty distinguishing adverbial clauses from other complex structures such as relative clauses and noun clauses, other than wh-noun clauses as described above. Furthermore, the Cx software was able to identity many forms that were ambiguous or were missed by one of the two examiners. Unlike manual raters, software such as Cx does not feel the effects of fatigue and thus has the potential to catch structures overlooked during manual analysis. Cx is easy to use, is distributed without cost, and is much faster than manual analysis, coding about 100-200 utterances per second.

Future research

The present study only tested the Cx software on two sets of samples. The accuracy of Cx in tagging language samples from other genres of spoken language, from children of other ages, or from culturally and linguistically diverse populations has yet to be examined.

Likewise, the Cx software only identifies utterances with finite adverbial, noun, or relative clauses. Non-finite adverbial, noun, or relative clauses are not attempted. Since these structures are infrequently used by children (Diessel, 2004), data with which to establish the probabilities used by the program are sparse. The absence of a consistent grammatical marker characterizing each particular syntactic construction would also make their identification much more difficult than recognition of finite adverbial clauses.

Conclusion

Language sample analysis is a valuable tool in the assessment of child language. Recognizing complex grammatical structures in a child's speech allows clinicians to understand a child's abilities and identify possible steps toward intervention. However, the process of manual language sample analysis is a complex task often neglected by clinicians (Kemp & Klee, 1997; Long, 1996). The accuracy of manual tagging may be affected by the syntactic proficiency and attentiveness of the clinician, and the required costs are high both for clinician training in grammatical analysis and for the time required to analyze language samples. Computer software capable of quickly and accurately locating complex grammatical structures could aid clinicians in understanding a child's abilities while easing or eliminating some of the costs associated with manual analysis. The findings of the current study suggest that the Cx software has potential to assist in and improve the quality of clinical language assessment.

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