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SYNTACTIC MATURITY
IN SCHOOLCHILDREN
AND ADULTS

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CONTENTS

ACKNOWLEDGMENTS

I. EARLIER MEASURES OF SYNTACTIC DEVELOPMENT

Schoolteachers have long felt that older children write sentences different from those written by younger children. They have also felt that the more mature sentences differ not just in vocabulary, and not just in subject matter, but also in syntax. For several decades educational researchers have tried to describe in objective, quantitative, and revealing terms what those syntactic differences are.

The motives for such research include of course the motives for much scientific inquiry: the desire to know, to see clearly what happens, and to describe it in verifiable terms. But in addition the researcher can hope that if he knew the normal stages of development this knowledge would have practical consequences. Such knowledge might enable the diagnostician to perceive deficiencies that would otherwise go unobserved. More importantly, it might enable curriculum designers to refine their objectives and devise means of hastening normal development in less time than is now required, and assure normal development for a larger proportion of children than now achieve it.

Ideally, syntactic development research would cover the full span of years from infancy to full maturity. But the techniques for describing the first utterances of the infant before he produces fully grammatical sentences (Brown & Fraser 1963; Menyuk 1961, 1963, 1964a, 1964b; Weir 1962) may be radically different from those techniques used to describe how the sentences of children just entering school differ from those of children graduating 12 years later. The earliest period is one of language acquisition; the other is one of language development. Just when it is that maturity is achieved and further development ceases for any individual is a matter for investigation, not one that can be settled by inference from what is known of general intellectual development. Ideally, language development research would also ask whether the syntactic performance of the average graduating senior differs significantly from that of the average adult and the skilled adult. The language arts teacher would like to know.

The terms in which syntactic development is investigated and described need to be objective in the sense that a second grammarian should be able

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to replicate the results. But objectivity is not enough: The terms must also be revealing in the sense that at least they must not contradict what we know intuitively and subjectively to be true. If some objective syntactic measure indicates that third-grade language is no different from twelfth-grade language, then we must conclude either that syntactic development does not occur between grades 3 and 12, which is contrary to any language teacher's subjective impressions, or that this particular measure is simply not revealing. Syntactic research has been a search for measures that are both objective and revealing. Its pages are littered with the debris of facts that are no doubt true but are also neither interesting nor revealing.

Some of the early studies counted the proportion of nouns, verbs, prepositions, and so forth used by children of various ages. Such a study is objective insofar as different investigators agree which words are nouns and which are other parts of speech. But Templin (1957) reports that the proportion used by 3-year-olds is about the same as that used by older children. So we must conclude that the distribution of parts of speech, although a quantitative and objective measure, is nonetheless not revealing for the study of later development.

Counting the proportion of interrogative, imperative, and declarative sentences employs another objective measure, but again it is not revealing because the situation in which the speaker or writer is responding will affect largely his choice of such sentences.

Conversely, researchers have employed measures that appear to be revealing but are not wholly objective. Such a measure is "sentence length" or "utterance length," whenever, in writing, a sentence is not defined as what is written between a capital and a period. Among those who have reported that the length of such units increases with maturity, as a revealing measure should, are Davis (1937), Heider and Heider (1940), McCarthy (1930), Stormzand and O'Shea (1924), and Templin (1957). But most investigators who use the measure acknowledge that subjective judgment is used in deciding whether to count a given passage as one "sentence" or two, one "utterance" or two. If such subjectivity is rarely needed, then two investigators should get closely similar results, and the measure could be called almost objective. But if such subjectivity is frequently employed, then the measure loses all claim to objectivity, regardless of how revealing it appears to be, regardless of how closely it tells us what our intuitive preconceptions also tell us.

As long ago as 1933 La Brant observed that "it is impossible to determine what constitutes a sentence in an individual's oral or written composition, unless the sentence be perfectly punctuated by marks or inflection" (p. 482). So she turned her investigation to what she called the clause rather than the sentence. Concerning the mean number of words per clause, she concluded, "Apparently length of clause is not a significant measure of language development for children in grades 4 to 12, inclusive" (pp. 467–468).

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However, that conclusion must be reassessed, for a third kind of difficulty is encountered here. Though what La Brant defined as a clause is objective enough, it is not what many school grammarians nowadays would call a clause. She cites the expression, "I am studying books and working hard." Here there is obviously one subject whose predicate consists of two verb phrases in the progressive form coordinated with *and*. One's linguistic theory might generate this structure from two deeper coordinated sentences—"I am studying books" and "I am working hard"—with the subject *I* and the auxiliary *am* appearing only once rather than twice in the final surface structure.

La Brant seems to have regarded the expression in some such light, for she goes on to comment that "predicates containing two or more participles or complementary infinitives after a single auxiliary were counted as two predicates." Such a procedure is fully objective. But she uses the "number of predicates" interchangeably with "number of clauses." To get "the average number of words per clause" she divided the "number of words" by the "number of predicates." Thus, the expression quoted earlier which has seven words and is counted as having two predicates would be assigned a "clause length" of three and one-half words.

This fact is important because many grammarians, at least today, would call this expression one clause, not two, and thus would assign it a clause length of seven words, not three and one-half. For this reason, as well as others, the general question of whether clause length, in the modern sense, increases with maturity needs to be reassessed.

Although La Brant concluded that the number of words per clause does not increase with maturity in schoolchildren, she found another measure which did increase significantly. Such a measure is the proportion of predicates in dependent, subordinate clauses as compared with the number of predicates in independent, main clauses. This measure she called the "subordination ratio" or "subordination index." She found that, of the total clauses written, older children write more and more subordinate clauses.

In addition to measures of parts of speech, words per "sentence," words per clause, and frequency of subordinate clauses, certain weighting scales have also been devised. Presumably, the higher the score the more mature the writing. One such scale, by Williams, assigns 1 point for a simple sentence, 2 for a compound sentence, 3 for a complex sentence, and 4 for a compound-complex sentence. On the basis of La Brant's conclusion that older children produce a greater number of subordinate clauses, it would seem reasonable to count more for a complex sentence than a simple sentence. But this scale also gives extra maturity points for compounding sentences, and at least one study will be cited later to indicate that fourth graders compound their written sentences more often than older students do. If such is indeed the case, then this weighting scale gives some credit for genuine maturity but weakens itself by giving credit also for immaturity.

The literature of syntactic research has been reviewed critically at

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various times. Nearly 30 years ago Heider and Heider (1940) summarized the studies previous to that time. A classic review was published by McCarthy in 1954. More recent reviews have been written by Carroll (1960), by Ervin and Miller (1963), and by Griffin (1968). Consequently, there is no need to review the literature again.

The research study to be reported on here is closely related to studies of syntactic development previously published by Hunt (1965) and by O'Donnell, Griffin, and Norris (1967). A review of those studies will facilitate an understanding of this new one.

In 1965 Hunt investigated the writing of schoolchildren in grades 4, 8, and 12, and later the writing of skilled adults, using one new syntactic unit and two older ones defined somewhat differently from the ways cited in some earlier studies. Setting aside any unintelligible passage or passage not syntactically complete, he counted as a sentence whatever the writer put between a capital letter and a period or other terminal mark. Such a measure is obviously objective, and it is not what some researchers have called a sentence. Within these sentences he counted as a clause any expression containing a subject or coordinated subjects and a finite predicate or coordinated predicates. Thus a clause could be "Jim and I went home," "I went home and rode my bike," or "Jim and I went home and rode our bikes." This definition differs from that of La Brant.

To attempt to count the number of words in a single clause is impossible and even meaningless in certain sentences, but it is always possible to count the number of words in a sentence and the number of clauses in it, and then compute the mean. Thus, in the following sentence there are four clauses and 21 words, giving a mean of 5.2, even though a grammarian might well point out that all words and all dependent clauses are part of the first and main clause: "The captain said, 'If you can kill the white whale, Moby Dick, I will give this gold to the one that can do it.'"

Hunt also introduced a new measure which he called a "minimal terminable unit" or "T-unit," which he defined as one main clause plus any subordinate clause or nonclausal structure that is attached to or embedded in it. The name "minimal terminable unit" was chosen because grammar textbooks usually say that a sentence must have one main clause but may also have one or more subordinate clauses and various kinds of phrases attached to or embedded in it. So cutting a passage into T-units will be cutting it into the shortest units which it is grammatically allowable to punctuate as sentences. In this sense, the T-unit is minimal and terminable. Any complex or simple sentence would be one T-unit, but any compound or compound-complex sentence would consist of two or more T-units.

How to segment a passage into T-units is illustrated with the following fourth grader's one-sentence theme. Here the sentence is printed so that each T-unit is numbered and begins a new line.

1. I like the movie we saw about Moby Dick the white whale
2. the captain said if you can kill the white whale Moby Dick I will give this gold to the one that can do it

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    3. and it is worth sixteen dollars
    4. they tried and tried
    5. but while they were trying they killed a whale and used the oil for the lamps
    6. they almost caught the white whale.

Using the concept of the T-unit as an intermediary structure between the clause and the sentence, Hunt used five measures that can be illustrated using the theme above. This theme happens to contain 68 words, 11 clauses, 6 T-units, and 1 sentence. Those four quantities give five ratios which will be shown to be useful measures for studying syntactic maturity: mean words per sentence (w/s) is 68/1 or 68, mean T-units per sentence (T/s) is 6/1 or 6, mean words per T-unit (w/T) is 68/6 or 11.3, mean clauses per T-unit or mean clauses per main clause (c/T) is 11/6 or 1.8, mean words per clause (w/c) is 68/11 or 6.2.

At least four of these five ratios are similar to some measure that has been used in earlier studies of syntactic maturity. For instance, what has been called sentence length, when *sentence* was used in some partly objective and partly subjective way, is somewhere between what is here called words per sentence and words per T-unit. The number of T-units per sentence is an index of how much coordination occurred between T-units, plus the number of run-on sentences, and so on, employed by younger students. What has been called the subordination ratio is here measured as the number of clauses per T-unit or number of clauses per main clause. What has been called clause length is here measured as the number of words per clause.

When these five measures are defined in this way, then it becomes true for any passage that w/c multiplied by c/T gives w/T, and w/T multiplied by T/s gives w/s. In view of that relationship, it is possible for the researcher to see how an increase in one of the five ratios affects certain other ratios, and in this way he can achieve a degree of understanding of syntactic maturity he could not achieve if the measures were not defined so as to be related in this fashion. Since these five measures relate clause length to sentence length, they have been called "a synopsis of clause to sentence length factors."

Hunt applied these five syntactic measures to the writing of nine boys and nine girls of average IQ (90–110) in each of three grades—4, 8, and 12—and to the nonfiction writings of 18 persons who had published in *Harper's Magazine* and in the *Atlantic*, whom he called skilled adults. From each writer he used a 1,000-word sample, getting a total corpus of 72,000 words. The schoolchildren's writing was the regular work done in English classes.

To the data received with these measures he applied various statistical tests, among them the contingency coefficient, to determine which of the five measures best discriminated the maturity of the various groups of writers. The results of that investigation appear in table 1.

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TABLE 1

A SYNOPSIS OF CLAUSE TO SENTENCE LENGTH FACTORS FOR FOUR GROUPS

	Words per Clause	Clauses per T-Unit	Words per T-Unit	T-Units per Sentence	Words per Sentence
Grade 4.........................	6.6	1.30	8.6	1.60	13.5
Grade 8.........................	8.1	1.42	11.5	1.37	15.9
Grade 12........................	8.6	1.68	14.4	1.17	16.9
For three grades, χ^2.............	33.10	17.66	50.66	3.07	17.03
Contingency coefficient for three grades........................	.616	.496	.694	.203	.489
Skilled adults...................	11.5	1.74	20.3	1.24	24.7
Contingency coefficient for four groups........................	.73	.51	.73	N.S.	.64

On the basis of these and other findings he came to the following conclusions about the syntactic development of the writing of schoolchildren between grades 4 and 12 and the writing of skilled adults.

a) As they mature from grades 4 to 12, schoolchildren tend to write more words per clause. Skilled adults carry that tendency substantially further.

b) As they mature, schoolchildren tend to write more clauses per *T*-unit, but skilled adults do not carry that tendency significantly further than twelfth graders.

c) Since words per *T*-unit is the arithmetical product of words per clause and clauses per *T*-unit, and since both measures increase with maturity through the school years, of course words per *T*-unit tend to increase also. Skilled adults carry the tendency still further because they write longer clauses.

d) As they mature, schoolchildren tend to write fewer *T*-units per sentence. Most of the reduction occurs between grades 4 and 8. Skilled adults write about the same number as schoolchildren in the middle and upper grades.

e) As they mature, schoolchildren tend to write more words per sentence. Skilled adults carry the same tendency still further, not because they produce more *T*-units per sentence but, instead, because their *T*-units are longer. Since words per sentence is the arithmetical product of words per *T*-unit multiplied by *T*-unit per sentence, and since the first measure tends to increase during the school years whereas the second tends to decrease, the result of the two conflicting tendencies is that words per sentence is not so good an index of maturity, at least during the early grades, as are certain other measures.

f) Taking the maturity of the average twelfth grader as the goal, the best of these indexes of syntactic maturity is words per *T*-unit; second best is words per clause; third best is clauses per *T*-unit; fourth best is words per sentence.

g) Taking the maturity of skilled adults as the goal, the results are about the same as in (*f*) above except that words per clause is as good an index as words per *T*-unit, instead of being second best.

Hunt also carried the investigation further in several directions. Looking into the fact that fourth graders write a large number of *T*-units per sentence, he found that this results from their tendency to put a large number of *and*'s between *T*-units. They do so three times as often as eighth graders and four times as often as twelfth graders. It may be conjectured that fourth graders feel the need to form larger constituents but have not yet acquired the syntactic means for doing so in a more mature way. In addition to producing an excess of *and*'s, fourth graders more often than older students tend to run *T*-units together without any coordinator or any punctuation between. He also tabulated the frequencies of the various coordinators and punctuation marks at all levels of maturity.

It is evidence such as this which casts doubt upon the adequacy, for the early grades, of any weighting scale which gives more maturity points for coordinated sentences than noncoordinated.

This tendency for younger children to write an immature number of *T*-units per sentence supports La Brant's aversion to studying sentence length and helps explain too why early investigators hesitated, in their search for an index of maturity, to accept as a sentence what the child actually wrote as such.

It being well established by La Brant and other investigators that older schoolchildren write more subordinate clauses, Hunt, like La Brant, Harrell (1957), and several others, tabulated the total number of movable adverb clauses, of relative adjective clauses, of noun clauses, and of other minor subclasses of subordinate clauses used at each grade. He did so to see whether maturity seemed to be demonstrated by an increase of one type more than another over several years. The evidence is far from conclusive, but he did find that the number of relative adjective clauses per *T*-unit increases almost fourfold from grade 4 to 12 and more than fivefold from grade 4 to skilled maturity. No other kind of subordinate clause increased so markedly over the years, though the proportion of one kind to another seems to vary with the subject matter.

Going down into the clause, whose length he found to increase markedly with maturity and skill, Hunt tabulated the phrase structure rules and the transformations that, according to the generative linguistic theory of the time, would produce each sentence in the corpus. He found only minor differences in the phrase structure rules employed by the various grades; he found, for instance, that older students elaborate the auxiliary by using significantly more perfect tenses, progressive forms, more passives, more modals. Although an expanded auxiliary would lengthen its own clause by a word or two, he found this kind of increase entirely too infrequent to explain the actually observed increase in clause length. He concluded that the fourth grader uses virtually all the phrase structure rules which produce

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what some grammarians have called the "basic sentence patterns," and that further study of them would not be generally revealing for schoolchildren in the middle and older grades.

Regarding the use of sentence-combining transformations, however, the results were remarkably different. He found that older writers, especially skilled adults, used a much larger number of sentence-combining, sentence-embedding, transformations per T-unit and per clause. He concluded that this tendency explained the actually observed increase in clause length with maturity, especially the maturity of skilled adults.

Furthermore, he found that those transformations which expand the nominal structures, as described by Lees (1960), are especially indicative of maturity.

In 1967, O'Donnell et al. used T-unit length as one of their measures in studying syntactic development in both the speech and writing of kindergarten and elementary schoolchildren. They report that "when fairly extensive samples of children's language are obtained, the mean length of T-units has special claim to consideration as a simple, objective, valid indicator of development in syntactic control." They found it useful in studying speech as well as writing and so ignored "sentence" length.

As subjects, these investigators studied 30 children in kindergarten and 30 in each of grades 1, 2, 3, 5, and 7. From all groups they got oral samples, and from the students in grades 3, 5, and 7 they got writing as well. The stimulus for both the speech and writing was the viewing of two short movies with the sound track turned off. After the viewing the students were asked to tell the story and then answer certain questions.

The findings from this study for writing in grades 3, 5, and 7 are close to those reported by Hunt for grades 4 and 8:

a) At every grade interval mean T-unit length increased with age. The values for each grade are close to those reported by Hunt (table 2).

b) The number of subordinate clauses per T-unit increased at every grade interval. The figures reported by O'Donnell et al. (1967) are fairly close to those reported by Hunt, though Hunt's figure for grade 4 is slightly higher than O'Donnell's for grade 5 (see table 2).

c) Although the O'Donnell study did not report the number of words per clause, it did report w/T and c/T in (a) and (b) above, and from those values the number of words per clause can be calculated for each grade. The values for clause length arrived at in this way increase at each grade interval and are fairly close to those reported by Hunt (table 2).

O'Donnell found that several of the development trends observed for writing also hold true for speech—and hold even in the earliest grades:

a) T-unit length in speech increases at every grade interval from kindergarten to grade 1, to grade 2, to 3, to 5, to 7.

b) The number of clauses per T-unit for speech did not increase at every interval; nonetheless the number did increase, though in a zigzag

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TABLE 2

T-UNIT LENGTH, CLAUSES PER T-UNIT, AND CLAUSE LENGTH

	G3	G4	G5	G7	G8
T-unit length:					
O'Donnell..........	7.67	...	9.34	9.77	...
Hunt..............	...	8.51	...	...	11.34
Clauses per T-unit:[a]					
O'Donnell..........	1.18	...	1.27	1.30	...
Hunt..............	...	1.29	...	...	1.42
Clause length:					
O'Donnell..........	6.5	...	7.4	7.7	...
Hunt..............	...	6.6	...	...	8.1

SOURCE.—Reported by Hunt (1965) and by O'Donnell et al. (1967).
[a] O'Donnell et al. reported the number of subordinate clauses per T-unit. Since each T-unit also contains one main clause, 1 plus O'Donnell's decimal gives all clauses per T-unit.

upward path. The values for kindergarten, and grades 1, 2, 3, 5, and 7 were, respectively, 1.16, 1.19, 1.18, 1.21, 1.19, 1.26.

c) The number of words per clause can be calculated from O'Donnell's published values for words per T-unit and subordinate clauses per T-unit. The values arrived at in this way increase at every successive grade. For the five grades, in order, the values are 6.1, 6.7, 7.1, 7.2, 7.5, 7.8.

The O'Donnell study also tabulated the number of sentence-combining transformations used by the students at each grade level both in speech and writing. In both modes of expression he found an increase in number at each grade interval. He concluded that the parallels between number of such transformations and T-unit length for each group were "impressive."

On the basis of Hunt's and O'Donnell's studies, and in the absence so far of contradictory data, there is evidence to believe that throughout the school years, from kindergarten to graduation, children learn to use a larger and larger number of sentence-combining transformations per main clause in their writing. Skilled adults carry the same tendency still further. In schoolchildren's speech the same tendency appears to exist up to the seventh grade, and future investigators may find that the tendency continues through the later grades.

This tendency explains the directly observable increase in number of subordinate clauses per T-unit, especially relative adjective clauses. It also seems to explain the directly observable increase in number of words per clause. These increases combine to explain why words per T-unit do, in fact, increase. Furthermore, the fact that young children coordinate T-units excessively and run them together without punctuation explains why words per T-unit is a more revealing measure of syntactic maturity than is the number of words per punctuated sentence.

It is this view of syntactic maturity that the present study is designed to amplify and refine.

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II. PURPOSE AND PROCEDURE

The general purpose of this study is to investigate the differences in the sentence structures (the syntactic structures) written by schoolchildren at various stages of chronological maturity and at various levels of mental ability within the same grade. The writing of certain adults is also studied.

The writings here examined differ from those examined by previous investigators in one important respect: here, all writers are saying virtually the same thing. By thus removing those variations in syntactic structure which might be due to differences in what two writers or groups of writers are saying, those other differences which are due only to the writer's syntactic maturity may be more clearly visible and measurable.

This study in which subject matter is maximally controlled supplements the earlier studies by the same investigator in which subject matter was minimally controlled—where the subject matter for the various grades was whatever the students happened to be writing in their English classes. The breadth gained by one kind of study is supplemented by the narrowness and precision possible in the other kind of study.

In the earlier studies by Hunt and O'Donnell clause length and *T*-unit length were found to increase significantly with maturity. That increase was attributed to the older writer's ability to use more sentence-combining, sentence-embedding, transformations per clause and per *T*-unit. In this study every writer is given the same set of extremely simple sentences to rewrite. Thus it is possible to observe directly exactly what syntactic transformations he does employ in rewriting. This study focuses on the following questions:

a) When students are asked to rewrite a passage written in extremely short sentences, do they exhibit the same general syntactic characteristics as they exhibit in their own free writing?

b) When students at various grade levels, and hence of varying ages, are all saying the same thing in writing, do the older students tend to say it in longer clauses?

c) Do they say it in longer *T*-units?

d) Do the older students tend to use more sentence-combining transformations?

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e) Is there a positive correlation between these three syntactic measures?

f) What other syntactic characteristics can also be discerned in the writing of more mature and more able students?

g) Do the syntactic characteristics referred to in (*b*), (*c*), and (*d*) above also hold true for students within the same grade but of different mental maturity?

h) Does this instrument measure syntactic maturity in a way that is less expensive than the analysis of large samples of students' original writing?

The Instrument

In 1965–1966 Dr. Roy O'Donnell undertook a pioneering experiment of the sort to be described here. He had students rewrite a passage which he had written in extremely simple sentences. His first instrument, a narrative entitled "The Old Man and the Hen," succeeded in eliciting longer *T*-units from students in the middle grades than in the lower, but failed to elicit still longer *T*-units from high school students. Nonetheless, it showed promise.

Six graduate students in the Florida State University research trainee program then wrote and tried out a dozen different new passages with various sets of instructions and, in small pilot studies, succeeded in eliciting successively longer clauses and successively longer *T*-units from students in lower elementary and high school grades. With this experience as background, O'Donnell was asked to write a new instrument on an expository subject, and it is this that the present study primarily relies on.

That instrument consists of 32 sentences of connected discourse. The sentences are shorter than those normally spoken or written by even kindergarten children: they average about four and one-third words. Each is a single clause.

The extremely short sentences were deliberately chosen to give abundant opportunities for the student to use many of the sentence-combining transformations that, according to the previous studies mentioned, older students do use with increasing frequency.

The instructions enjoin the student to rewrite the passage "in a better way." No further suggestions would have been given about the "better way" had it not been for the discovery during the pilot studies that, when students were allowed to feel perfectly free to make changes, they added and subtracted so much material that various students could no longer be said to be "saying the same thing." So the directions to the student had to specify what he was allowed to change and what he was not.

The actual directions and the passage were as follows:

Aluminum

Directions: Read the passage all the way through. You will notice that the sentences are short and choppy. Study the passage, and then rewrite it in a better

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way. You may combine sentences, change the order of words, and omit words that are repeated too many times. But try not to leave out any of the information.

Aluminum is a metal. It is abundant. It has many uses. It comes from bauxite. Bauxite is an ore. Bauxite looks like clay. Bauxite contains aluminum. It contains several other substances. Workmen extract these other substances from the bauxite. They grind the bauxite. They put it in tanks. Pressure is in the tanks. The other substances form a mass. They remove the mass. They use filters. A liquid remains. They put it through several other processes. It finally yields a chemical. The chemical is powdery. It is white. The chemical is alumina. It is a mixture. It contains aluminum. It contains oxygen. Workmen separate the aluminum from the oxygen. They use electricity. They finally produce a metal. The metal is light. It has a luster. The luster is bright. The luster is silvery. This metal comes in many forms.

The Subjects

This instrument, together with another which will be referred to later, was administered to more than a thousand students in grades 4, 6, 8, 10, and 12 in the public schools of Tallahassee, Florida. They were allowed to spend as much as a full class period on this instrument. The students were almost exclusively white. Steps were then taken to select from each grade 50 students who would represent something close to a normal distribution of academic ability. A normal curve for 50 subjects was divided into intervals the width of one-half a standard deviation, and the number of subjects that would be needed to fill each of those intervals was then calculated. However, to avoid the necessity for finding students with extremely high and low scores, the three intervals at the extreme ends of the bell curve were merged into one interval representing 1.5 standard deviations rather than 0.5. Then, on the basis of their scores on certain standardized tests, the number of students needed to fill each of these intervals were chosen at random.

The standardized tests which had already been administered to these students were, for grades 4 and 6, the California Achievement Test; for grades 8 and 10, the California Test of Mental Maturity; for grade 12, the Florida Twelfth Grade Test. It was on the basis of scores on these tests that the distribution was made. As Cronbach (1949) says, "The correlation of mental tests with tests of achievement is high." In reporting the statistical results, the label SS for Standard Score is used to designate the students' scores on the standardized ability or achievement tests.

These 50 students from each grade were further subdivided into three groups of approximately equal size according to their scores on the standardized test scores: 17 formed the "high" third, 16 the "middle" third, 17 the "low" third. The actual mean scores of the 17 students in the high-ability group for each grade were, in percentiles, from 82.6 to 83.6; in IQ scores, from 116.9 to 117.5. For the 16 students in the middle third for each grade, actual mean scores were, in percentiles, 48.1 to 50.2; in IQ scores, from 100 to 101.3. For the 17 students in each low group the actual mean scores were, in percentiles, from 16.8 to 18.4; in IQ scores, from 79.4 to

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84.4. In other words, the actual mean scores of the three groups for each grade did not differ significantly from what they would have been in a perfectly normal distribution.

In addition to the schoolchildren, two groups of adults rewrote this same instrument. One group of adults can appropriately be called "skilled." Whether the other group can appropriately be called "average" is open to considerable question, but at least there is no obvious reason to suppose they were superior or inferior in writing ability to what "average" would be.

The skilled adults were asked to write in order to see whether they carried still further the tendencies manifested by the schoolchildren. And once it was determined that they did so, the other group of adults was asked to write in order to see whether age alone, rather than skill, was responsible for the difference between twelfth graders and skilled adults.

At first, the performance of the schoolchildren will be described separately from that of the two adult groups, since the two adult groups are not, in all senses, a continuation of the five groups of schoolchildren. They fail to be an extension in the sense that the age and IQ of the skilled adults were not ascertained, nor was the IQ of the average adult. They are, however, an extension in the sense that all are older and that the skilled adults carried further the developmental trends of the schoolchildren. So, after the performance of the five groups of schoolchildren is described, a summary of all seven groups will also be given.

Procedure

After the students' papers were typed, the writings were screened to exclude extraneous, unintelligible, or inaccurate passages. Where such a passage was found, the whole sentence containing it was deleted. Passages such as the following were judged to contain inaccurate or unintelligible material:

The luster is silvery *that comes in many forms.*
They take the mass substances out by using filters then they put it in *several other substances because a liquid remained.*
They grind it and put it in *remove mass with use filters.*

Passages such as the following were judged extraneous:

This is a nonfiction story about aluminum.
This metal, *like I said before,* has many uses and comes in varied forms.

The First Stage of Syntactic Analysis

The syntactic analysis[1] then proceeded in two stages, the second of which will be discussed in Chapter IV. The first stage consisted of counting the number of words, the number of clauses, the number of *T*-units, and the number of sentences in each piece of writing. The criterion used to decide

[1] The graduate trainees who performed the analysis were Max Morenberg, Mike Pope, James Richardson, Andrew Rogers, Jr., William L. Smith, and Louise Todd Taylor.

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whether a certain expression was to be counted as a clause was the same as that which appears in most schoolbook grammars: the expression must contain a subject (or coordinate subjects) and must contain a finite verb (or coordinate verbs). Whatever a student wrote between an initial capital letter and a period or other terminal mark was counted as a sentence. The criterion for a T-unit was that it consist of one main clause plus whatever subordinate clauses and nonclausal expressions are attached to or embedded within it.

The numbers of words, clauses, T-units, and sentences for each piece of writing were then used in figuring the five ratios that in previous research have been called the synopsis of clause to sentence length factors. Those five synopsis measures are: mean words per clause (clause length), mean clauses per T-unit (subordinate clause index), mean words per T-unit (T-unit length), mean T-units per sentence (main clause coordination index), mean words per sentence (sentence length).

Taking those scores for each student's writing, means were then computed for each grade as a whole and also for the high-, middle-, and low-ability groups within each grade. Appropriate statistical tests for significance were then made. An analysis of variance was made to see whether the differences from one grade to another were significant, whether the differences from one ability group to another within each grade were significant, and whether the interaction of grade and ability group was also significant. If the analysis of variance showed a syntactic measure to be significantly different for ability groups across all grades taken as a whole, then the Newman Keuls test was made to see between which grades the differences were significant. Pearson product moment correlations were also determined between the ability or achievement scores and the various syntactic measures at each grade level. The results of these various statistical tests will be reported as the findings for each of the five synopsis measures are discussed.

III. FINDINGS: A SYNOPSIS OF CLAUSE TO SENTENCE LENGTH FACTORS

Sentence Length

In the writings for this study there is some rough correspondence between sentence length and maturity. At least it is true that the three older grades write longer sentences than the two younger grades (as table 3 indicates). But little more can be said in defense of this index. It fails at several points. For instance, of the two younger grades the older one writes sentences that are shorter rather than longer. And among the three older grades, tenth graders write shorter sentences than the younger eighth graders. To point out further inadequacies, at the two younger grades the two high-ability groups write shorter sentences than their less able classmates.

TABLE 3

SENTENCE LENGTH

	G4	G6	G8	G10	G12
Low group............	9.37	8.99	10.37	11.42	11.66
Middle group.........	9.71	8.96	12.40	11.15	12.18
High group...........	8.59	8.42	12.45	12.44	12.66
All groups............	9.21	8.78	11.73	11.68	12.17
Standard deviation.....	3.21	2.08	2.43	2.44	2.96
Correlation with SS....	−.137	−.160	−.406	.137	.145

	SS	df	MS	F
	Analysis of Variance			
Source:				
Grade.....................	499.84	4	124.96	17.64*
Ability....................	16.15	2	8.07	1.15
G × A....................	69.58	8	8.69	1.22
Error.....................	1643.06	235	6.99	...
Total....................	...	249	...	...

NOTE.—Newman Keuls: 6 4 10 8 12.

* $p < .01$.

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The analysis of variance indicates significance for grade but not for ability or for the interaction of grade and ability.

In brief then, older students do write longer sentences, but the relation to either chronological or mental maturity is very rough. The findings of this study support Hunt's findings from studies of free writing.

Main Clause Coordination Index

Of the several ways to write longer sentences, one immature way is to string together a great number of main clauses with *and*'s or nothing between.

This tendency observed in students' freer writing is also clearly apparent in the controlled content writings for this study, as demonstrated in table 4. That table shows the average number of main clauses per sentence written by students in each grade. It also shows the number written by each ability group within each grade.

At every grade level there is a decrease, at first a sharp one, then a more gradual one. Furthermore, within each grade there is a clear tendency for the more able students to coordinate main clauses *less* often than their less able classmates. This developmental tendency is demonstrated in greater detail in this study than it has been before.

The analysis of variance indicates significance for grade, for ability, and for interaction of grade and ability.

The facts concerning this tendency help to explain why, as noted in the previous section, the sentences written in this study by fourth graders are longer than those written by sixth graders. The fourth graders make

TABLE 4

MAIN CLAUSE COORDINATION INDEX

	G4	G6	G8	G10	G12
Low group............	1.782	1.647	1.410	1.215	1.148
Middle group..........	1.936	1.240	1.243	1.070	1.060
High group............	1.512	1.132	1.083	1.105	1.035
All groups.............	1.739	1.342	1.245	1.131	1.082
Standard deviation.....	0.63	0.48	0.26	0.19	0.11
Correlation with SS....	−.262	−.448	−.501	−.266	−.553

	SS	df	MS	F
		Analysis of Variance		
Source:				
Grade......................	13.85	4	3.46	25.77**
Ability....................	3.03	2	1.51	11.37**
G × A.....................	2.21	8	0.27	2.05*
Error.....................	31.19	235	0.132	...
Total....................	...	249	...	...

NOTE.—Newman Keuls: 12 10 8 6 4.
* $p < .05$.
** $p < .01$.

them long by excessive coordination of main clauses. This finding also supports and makes clearer those from Hunt's study of free writing.

T-*Unit Length*

The *T*-unit length of the writing in this controlled content study increases unmistakably with age and with ability within grade. Table 5 shows an increase at every grade interval. And within each grade there is an increase at every ability level except the very first, where middle fourth grad-

TABLE 5

T-UNIT LENGTH

	G4	G6	G8	G10	G12
Low group.............	5.23	5.73	7.55	9.61	10.17
Middle group..........	5.21	7.34	10.34	10.46	11.45
High group............	5.81	7.47	11.66	11.66	12.30
All groups.............	5.42	6.84	9.84	10.44	11.30
Standard deviation.....	1.13	1.54	3.06	2.11	2.54
Correlation with SS....	.294	.443	.578	.305	.387

	SS	df	MS	F
	Analysis of Variance			
Source:				
Grade......................	1268.45	4	317.11	77.06**
Ability.....................	179.75	2	89.87	22.03**
G × A......................	63.54	8	7.94	1.93*
Error......................	954.60	235	4.06	...
Total.....................	...	249	...	...

NOTE.—Newman Keuls: 4 6 8 10 12.
* $p < .10$.
** $p < .01$.

ers have almost the same mean score as the low fourth graders. The correlation with achievement scores is positive and significant at the .05 level for every grade, including the fourth.

The analysis of variance indicates significance for grade and for ability but not for interaction of grade and ability.

The fact that *T*-unit length goes steadily up while *T*-units per sentence goes down explains why sentence length varies irregularly in this study. As was found in Hunt's previous studies of free writing, *T*-unit length is clearly a better index of syntactic maturity than sentence length.

Subordinate Clause Index

What is here called the subordinate clause index is simply the ratio of all clauses (both subordinate and main) per main clause. Table 6 shows that the number of subordinate clauses did indeed increase: it increased quickly for 4 years, from grades 4 to 6 to 8. But then it leveled off from grades 8 to 10 to 12.

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TABLE 6

SUBORDINATE CLAUSE INDEX

	G4	G6	G8	G10	G12
Low group..............	1.039	1.074	1.230	1.387	1.362
Middle group..........	1.003	1.237	1.461	1.412	1.484
High group............	1.085	1.237	1.601	1.458	1.481
All groups.............	1.043	1.182	1.430	1.419	1.441
Standard deviation.....	0.108	0.195	0.293	0.19	0.269
Correlation with SS....	.259	.314	.559	.123	.243

	SS	df	MS	F
	Analysis of Variance			
Source:				
Grade.....................	6.56	4	1.64	37.08**
Ability...................	1.03	2	0.51	11.78**
G × A....................	0.71	8	0.08	2.01*
Error....................	10.27	235	0.043	...
Total...................	...	249	...	...

NOTE.—Newman Keuls: 4 6 <u>10 8 12.</u>
* $p < .05$.
** $p < .01$.

Clause Length

It is no wonder that studies in syntactic development have paid relatively little attention to clause length. Growth in clause length appears to be so very slow that an investigator studying it in successive elementary grades, or successive high school grades, or in two groups of students in the same grade is likely to find no difference at all.

Nonetheless, more than 30 years ago La Brant (1933) noted that eminent psychologists used clauses twice as long as those of her schoolchildren.

Over the whole span of the school years, and into the maturity which the skilled writer develops, there can be no doubt that clause length as measured here does increase. Though it moves with glacial slowness in the early grades, sensitive instruments and closely controlled studies can be expected to detect it, and studies covering a long period of time can hardly miss it.

The findings of this study concerning clause length appear in table 7. They show an extremely close relation to age and ability grouping. At every grade interval there is a significant increase, and among all the ability groups there is also an increase. Furthermore, within every grade the difference between the high group and the low is statistically significant at the .05 level by the Wilcoxon rank sum test. The analysis of variance indicates significance for grade, for ability, but not for interaction of grade and ability. The Newman Keuls test indicates that the difference is significant between every pair of grades. In other words, clause length as measured in response to this instrument is an extremely sensitive measure of some factor which is closely related to chronological age and mental ability.

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TABLE 7

CLAUSE LENGTH

	G4	G6	G8	G10	G12
Low group.............	5.04	5.31	6.09	6.87	7.42
Middle group..........	5.19	5.92	6.98	7.39	7.72
High group............	5.33	6.05	7.30	7.81	8.39
All groups.............	5.19	5.76	6.79	7.35	7.85
Standard deviation.....	0.88	0.71	1.12	1.12	1.20
Correlation with SS....	.190	.425	.559	.368	.340

	SS	df	MS	F
		Analysis of Variance		
Source:				
Grade......................	242.29	4	60.57	64.30*
Ability....................	29.52	2	14.76	15.80*
G × A....................	5.65	8	0.70	0.74
Error......................	218.52	235	0.93	...
Total.....................	...	249	...	...

NOTE.—Newman Keuls: 4 6 8 10 12.
* $p < .01$.

The major concern of the following sections will be to note in general just what it is that successively older students do to produce their longer clauses.

The Performance of Skilled Adults

A very important question to ask about the findings of this study is whether these developmental tendencies are characteristic of schoolchildren alone and counter to the practices of "good writers." Do, in fact, "good writers" reverse the tendencies described here?

To answer that question the same instrument which was given to the schoolchildren was sent also to a considerable number of persons who in recent months had published nonfiction articles in *Harper's Magazine* and in the *Atlantic*. Accompanying the instrument was a letter soliciting their aid, telling them the purpose of the experiment, and promising them a copy of the final report if they would participate. They were told nothing about the kinds of measurements to be used. In all, 95 people had to be asked before 25 returned the passage rewritten. Of those who thus complied with the request, one or two protested that it could not be rewritten adequately; but one said it was an inviting problem, and he sent along a couple of versions written by friends of his.

There is no way to know whether the skilled adults spent more or less time than the schoolchildren did rewriting the passage. No one could compare their writings with the writings of schoolchildren and fail to sense the greater resources that most, if not all, the skilled adults demonstrated. They felt more freedom with the assignment, as if they were willing to take this

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information and rewrite it, but not until they had absorbed it and made it their own.

The five synopsis scores on everything the skilled adults wrote appear in table 8 along with the means for each grade of schoolchildren. For each of the five measures, skilled adults carry still further the trends already

TABLE 8

SYNOPSIS SCORES FOR SCHOOLCHILDREN AND ADULTS

Item	G4	G6	G8	G10	G12	Average Adults	Skilled Adults
w/c........	5.19	5.76	6.79	7.35	7.85	8.40	9.95
c/T........	1.043	1.182	1.430	1.419	1.441	1.47	1.51
w/T........	5.42	6.84	9.84	10.44	11.30	11.85	14.78
T/s........	1.739	1.342	1.245	1.131	1.082	1.06	1.05
w/s........	9.21	8.78	11.73	11.68	12.17	12.51	15.22

described as characteristic of syntactic maturity in schoolchildren. No trend is reversed. There is no evidence whatsoever that the schoolchildren are moving in a wrong direction.

The difference in clause length is particularly notable. Of the 25 skilled adults, 23 wrote longer clauses than the average for twelfth graders as a whole, and 22 wrote longer clauses than the mean for superior twelfth graders. One suspects that one or two of the skilled adults with the lowest scores felt they were writing down for children, but of course this impression is not verifiable. The superiority of skilled adults over twelfth graders is 2.10 words, four-fifths as great as the superiority of twelfth graders over fourth graders. This supports the conclusion Hunt came to after studying the free writing of skilled adults: that if the average high school graduate is ever to write like a skilled adult, he has nearly as much yet to learn about how to embed more clauses as he learned in all of his public school years.

The Performance of "Average" Adults

To get a population that could be defended as being strictly average high school graduates pursuing a strictly average occupation a certain number of years after graduation would be more of an undertaking than was feasible as part of this study. But what may or may not be an approximation of average adult writing was obtained and studied. Writing was obtained from 25 men who were high school graduates, had not attended college, and were all employed as firemen in Tallahassee, Florida. Firemen were chosen simply because their occupation could be assumed not to require extensive daily reading, because the group would be immediately recognizable by readers of this study, and because it was assumed that they would be willing to do the rewriting. The average age of the 25 chosen turned out to be 32, the median age 29, so it could be said that the average

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had been out of high school for a decade or more. As table 8 shows, their clause length and T-unit length are superior to that of average twelfth graders; however, the difference is not statistically significant. They are, at the same time, below skilled adults in those same two respects, and those differences by the Wilcoxon rank sum test are significant at the .01 level.

On the basis of this sample, small and uncertain as it is, one might hazard the conclusion, tentatively at least, that the average twelfth grader at the time of his graduation is about as mature syntactically as he will ever be, at least unless he gets further training or goes into an occupation requiring special language skill, and, even if he did, it is not known whether such training or practice would raise his syntactic achievement.

Summary

With these findings, some of the original questions are now answered:

a) When students are asked to rewrite a passage written in extremely short sentences, they do exhibit the same general syntactic characteristics they exhibit in their own original compositions. The trends shown here for the five syntactic measures are the same as those shown in free compositions. The same things can be said of skilled adults.

b) Older students tend to write significantly longer clauses. The means are significantly different at every 2-year interval. Skilled adults write significantly longer clauses than twelfth graders.

c) Older students tend to write significantly longer T-units. Across three of the four 2-year intervals the means are significantly different. Skilled adults write significantly longer T-units than twelfth graders.

d) Within each of the five grades, the mean clause length of the high-ability group is above that of the middle-ability group, and their mean, in turn, is above that of the low-ability group. Within each grade, the difference between the high and low groups is statistically significant at the .05 level.

e) Within all but the fourth grade, the mean T-unit length of the high-ability group is above that for the middle, and the mean for the middle group is above that for the low.

f) On this instrument, of the five syntactic measures so far discussed, clause length is the one most closely related to chronological age and mental age. It is sensitive enough to show a significant difference in a 2-year interval and also between the high third and low third within a grade.

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IV. FINDINGS: HOW THESE CLAUSES GREW

Transformational grammarians have made familiar to may teachers the process by which two strings of formatives, either of which could underlie an actual sentence, are combined to produce one larger string of formatives which can, in turn, underlie one new and longer sentence. "Aluminum is a metal" plus "It is abundant" becomes "Aluminum is an abundant metal." Such an enlarged string can be combined again with another to produce a still longer string. "Aluminum is an abundant metal" plus "It has many uses" becomes "Aluminum is an abundant metal with many uses." It is this process which makes it possible for a speaker or writer to produce an infinite variety of sentence structures of unbounded length. In early writings on transformational syntax (Chomsky 1957; Lees 1960), sentence-combining transformations operated on only two strings at a time, but the process could continue indefinitely.

More recent versions of transformational grammar (Chomsky 1965; Katz 1966) do not represent complicated sentences as being built by a process that combines sentences only two at a time. Instead they show the relation of three or more all at once. The simplified base phrase marker in figure 1 shows at the same time three sentences underneath S constituents. Two of the S constituents are embedded within the uppermost S.

From this one phrase marker a variety of sentences can be produced, among them these four:

a) Aluminum is an abundant metal which has many uses.
b) Aluminum is a metal which is abundant and has many uses.
c) Aluminum is an abundant metal having many uses.
d) Aluminum is an abundant metal with many uses.

Though these four have different connotations, perhaps, and different stylistic nuances, they all can be said to mean the same thing in the sense that if one is true the others are true, and if one is false the others are false. All four have the same deep structure, as is shown in the tree diagram.

What differentiates the four is that different sets of transformations have been used in converting the deep structure into the four surface struc-
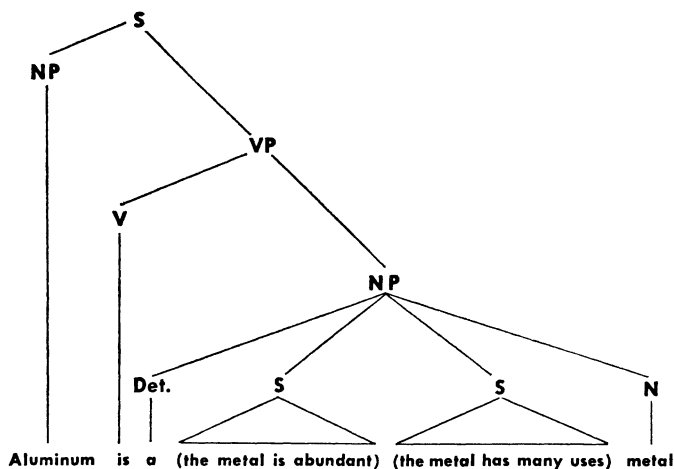
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FIGURE 1.—Branching diagram

tures which underlie (a), (b), (c), and (d). For instance, the input main clause "The metal has many uses" has been transformed into a subordinate clause, "which has many uses," in (a). It is transformed into a full predicate, "has many uses," in (b), and into other nonclausal structures, "having many uses" and "with many uses," in (c) and (d).

The first stage of analysis tabulated, among other things, the total number of main clauses and subordinate clauses for each writer, each grade, and each group. The second stage was more detailed. It studied whatever syntactic changes were made to each one of the 32 input sentences as it passed through the mind of each writer. Some 9,000 tabulations of this sort were made.

Each original input sentence was a single clause, by definition a main clause. Some of these were retained as main clauses, some were reduced to subordinate clauses, and the number so handled have been reported in the previous chapter.

Other input sentences were reduced to less than a clause. To be reduced to what is here called "less" than a clause, the input sentence would need to have deleted either its subject or its predicate or enough of its predicate structure that it no longer was a finite verb phrase. In rewriting the Aluminum passage, no full predicates happened to be deleted—that is, no subjects were coordinated. However, many full predicates were coordinated and many input sentences were reduced to less than full predicates: perhaps only the direct object survived, or an adjective. The nonclausal structures described here were, of course, all embedded in some other clause.

In the following chapter a tabulation will be given of the syntactic changes made on each of the input sentences reduced to less than a clause. In the following sections of this chapter the total number of such syntactic

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changes will be reported for each grade and group. Those numbers will be discussed as an index of maturity and will be related to the observed increase in clause length.

Coordinated Predicates

When two sentences have the same subject, one subject can be deleted, and the remaining full predicate can be coordinated with the other predicate. "It is abundant" plus "It has many uses" becomes "It is abundant and has many uses." This transformation reduces a clause to less than a clause.

Table 9 shows the mean number of such transformations per writer in each grade and ability group. The norm is about two per person regardless of age or ability. No developmental trend is evident either between grades or between ability groups. Apparently fourth graders have learned to make this transformation about as often as older students. Whatever syntactic growth is in store for them will occur in other directions.

Reductions to Less than a Predicate

In contrast with the transformation just mentioned, which retains the full predicate, there are many transformations which embed one S constituent in another after deleting more than just the subject. In addition to the subject, some also delete the finite verb marker, or tense marker, replacing it

TABLE 9

CoORDINATE PREDICATES, LESS THAN PREDICATES, LESS THAN CLAUSES

	G4	G6	G8	G10	G12	Average Adults	Skilled Adults
Coordinate predicates:							
Low group.....	1.35	1.65	2.00	2.70	2.06	...	...
Middle group...	1.62	2.69	2.38	1.81	2.63	...	...
High group....	2.59	2.35	2.35	1.53	1.24	...	...
All groups.....	1.86	2.22	2.24	2.02	1.96	1.88	1.6
Less than predicates:							
Low group.....	1.06	3.47	6.58	10.70	11.11	...	...
Middle group...	1.37	5.50	10.56	12.50	13.19	...	...
High group....	2.53	8.94	12.05	14.23	16.23	...	...
All groups.....	1.66	5.98	9.72	12.48	13.52	14.00	17.7
Correlation with SS..........	.484	.413	.580	.497	.574	...	...
Less than clauses:							
Low group.....	2.41	5.12	8.58	13.40	13.17	...	...
Middle group...	2.99	8.19	12.94	14.31	15.82	...	...
High group....	5.12	11.29	14.40	15.76	17.47	...	...
All groups.....	3.52	8.20	11.96	14.50	15.48	15.88	19.3
Correlation with SS..........	.403	.466	.614	.472	.513	...	...

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with a *to* or *-ing:* "They grind the bauxite" becomes ". . . grinding the baux-
ite . . ."; "Workmen separate the aluminum" becomes ". . . separating the
aluminum . . ." This is one way in which structures are reduced to less than
a full predicate. Other transformations replace certain verbs with, perhaps, a
preposition: "It has many uses" becomes ". . . with many uses . . .," again
something less than a predicate. Or the verb, especially a copula, is deleted:
"Bauxite is an ore" becomes "bauxite, an ore," an appositive, and something
less than a predicate.

Table 9 presents the mean number of such transformations per writer
in each grade of schoolchildren and each ability group, and also for average
and skilled adults. A developmental trend is clearly evident. At every grade
interval there is an increase, and each difference is significant at the .05 level
at least, by the Wilcoxon rank sum test. Furthermore, within each grade
the high group is above the middle group and the middle above the low, and
the difference between each high group and low is again statistically signif-
icant, at the .005 level by the Wilcoxon rank sum test. Skilled adults carry
the developmental trend still further.

Reductions to Less than a Clause

The number of reductions to less than a clause is a useful measure
because, as will be shown, it is the developmental increase in the number
of these that explains the developmental increase in clause length.

The number of these reductions for any passage is simply the total of
coordinated predicates and reductions to less than a predicate, since it
happened in this study that no subjects were coordinated. There would have
been no need to tabulate separately the two subgroups except to show that
one subgroup is not an index of development, at least above the fourth
grade, whereas the other is a highly sensitive and discriminating index
of development at all levels.

The number of these reductions is shown in table 9 for each grade
and ability group of schoolchildren and for the adults. Since these scores
are highly influenced by the number of reductions to less than a predicate,
which is so clearly of developmental significance, it is no surprise that these
scores too are clearly of developmental significance. At every grade interval
there is an increase that is statistically significant at the .05 level, at least,
by the Wilcoxon rank sum test. Within each grade the high group is
above the middle and the middle above the low. Furthermore, the difference
between every high and low group is significant at the .005 level by the
Wilcoxon rank sum test. This measure, like the number of reductions to less
than a predicate, is a highly sensitive and significant measure of chronolog-
ical and mental maturity.

The correlations between scores for reductions to less than a clause and
reductions to less than a predicate for all schoolchildren is 0.96, almost
perfect.

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Less Than a Clause and Clause Length

Earlier in this study the argument was presented that the older writer's superior ability to use more sentence-combining transformations explains the fact that the older writer's clauses are longer than those of the younger writer. To examine that argument in more detail, let us suppose, contrary to fact, that input sentences, or all strings in an S constituent, contain exactly the same number of words, say five. And suppose that every sentence-combining transformation deletes exactly the same number of words, say three, leaving the remaining two to be embedded in some clause. If such were the case, then the correlation between the number of transformations and the mean number of words per clause would be perfect for any passage.

But of course the supposition is contrary to fact. Even in a sample no larger than the Aluminum passage, the input sentences vary in length from three to eight words. Furthermore, not all transformations delete the same number of words. The writer who produces "Aluminum is an abundant metal" has retained only one word from the sentence "It is abundant," whereas the writer who produces "Aluminum is a metal with many uses" has retained three words from "It has many uses," yet both have used one transformation. Or take another example: Confronted by the two sentences "Bauxite contains aluminum" and "Bauxite contains several other substances," one way to combine them is by conjoining. Either one subject can be deleted or one subject and one verb. To delete the second subject alone and embed what remains in some other clause will lengthen the other clause by five words counting the *and,* whereas deleting the second subject and also the verb will lengthen the other clause by only four words. Yet the empirical fact is that the transformation which adds only four words to the other clause happens to be more mature than the one which adds five words. So in this particular instance it is not true that greater clause length means greater syntactic maturity.

In view of examples like these, we cannot expect a perfect correlation between the number of sentence-combining transformations and the number of words per clause.

However, the fact remains that the various input sentences and the various S constituents in any deep structure are sufficiently close to the same length on the average, and the number of words deleted by the various transformations that produce nonclauses is sufficiently close to the same, on the average, that we can expect a positive and significant correlation between the one measure and the other, if the sample is not too small.

The alternative hypothesis to explain the fact that older writers do write longer clauses would be either that they select those phrase structure rules which produce longer kernels or that they select those transformations which delete fewer words. Such a supposed selection seems absurd on the face of it. Furthermore, in this study there is absolutely no evidence to support it. Older writers worked with the same input sentences as younger ones

and used all the transformations younger ones used. As will be shown in the next chapter, they simply used a larger number of all kinds.

To see just how close the relation is between the actual number of reductions to less than clause and the number of words per clause, a correlation was run between those two scores for all of the 250 schoolchildren. The correlation turned out to be .87, a very high score considering that 1.0 is perfect and a score as low as .15 would still be significant at the .01 level.

Correlating the number of reductions to less than a predicate, instead of less than a clause, with words per clause, the results are virtually the same: .85 for the 250 schoolchildren, still .85 when the skilled adults are also included.

A Summarizing Diagram

The performance of the various writers with respect to these groups of transformations, as described in this chapter and the previous one, can be summarized and put in perspective by figure 2. Here, in a series of bars,
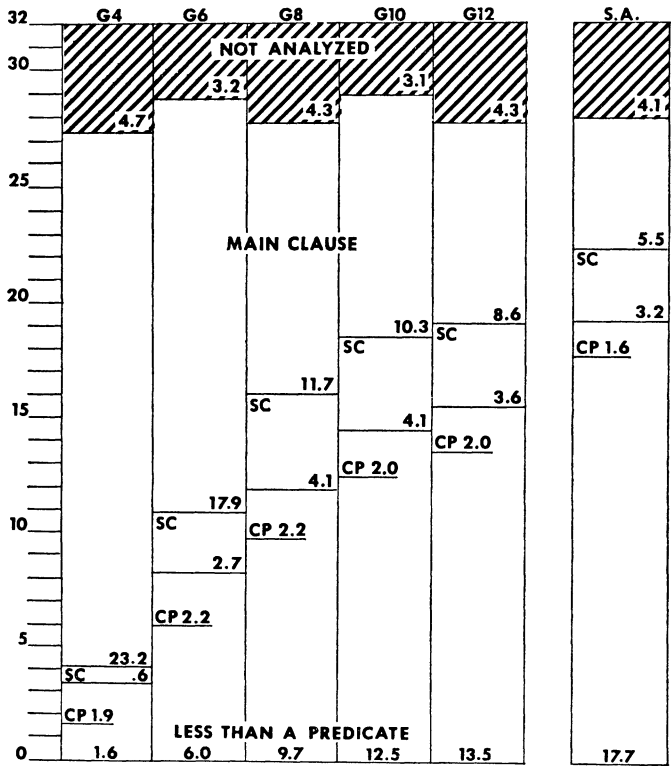

FIGURE 2.—Summary of syntactic structures

is shown what was done to the 32 input sentences by each group of writers.

A few of those input sentences never appeared in the output which was analyzed. Either the writer forgot them, or he intentionally omitted them, or they were excluded by the analysts because they appeared in a sentence containing extraneous or inaccurate information. What is important for comparison here is that the number not analyzed was about the same for each grade, 4 plus or minus 1. About 28 of the input sentences were re-written in some form by each grade.

a) Of those 28 or so input sentences that survived to be analyzed, successively older grades retained a smaller and smaller number as main clauses. In order of maturity, the number retained by each group was 23.2, 17.9, 11.7, 10.3, 8.6; skilled adults 5.5. The developmental trend is clear. The remaining number of input sentences were reduced to subordinate clauses or to nonclausal structures.

b) The number reduced to subordinate clauses increased up to the middle grades and then declined. For successively older groups the number was 0.6, 2.7, 4.1, 4.1, 3.6; skilled adults 3.2. Compared to the large change in number of main clauses, the change in number of subordinate clauses is relatively small. Those remaining input sentences that were not retained as main clauses and were not reduced to subordinate clauses were reduced to nonclausal structures, to less than clauses.

c) Some were reduced to full predicates coordinated with another predicate, and that number, indicated as *CP* on figure 2, is relatively constant.

d) The remaining number of input sentences were reduced to less than a full predicate. The number of them increases greatly with successively older groups and is, respectively, 1.6, 6.0, 9.7, 12.5, 13.5; skilled adults 17.7, more than 10 times as many as fourth graders.

e) Taking the figure as a whole, certain changes are relatively unimportant: the changes in subordinate clauses and coordinated predicates. The changes which are clearly inportant are the decrease in main clauses and the corresponding increase in reductions to less than a predicate.

f) One way to express this developmental relation is to calculate the number of S constituents, both clausal and nonclausal, that were, on the average, embedded within each main clause, each *T*-unit, by each group of writers. For successively older groups the figures are 0.13, 0.6, 1.4, 1.8, 2.2; skilled adults 4.1. In other words, a fourth grader embeds a second reduced sentence inside a main clause, a *T*-unit, only about an eighth of the time, whereas a skilled adult usually embeds four other reduced sentences within his main clauses or *T*-units. The tree diagram with which this chapter began (figure 1) would need to show four subsidiary S constituents for the typical skilled adult sentence. It would show less than one for fourth graders and sixth graders.

g) Calculating the number of embeddings within the average clause, either main or subordinate, as an index to show how clauses get longer, we find, for successively older grades, that the figures are 0.15, 0.4, 0.8, 1.0,

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1.3; skilled adults 2.2. One skilled adult consolidated the first six sentences of the Aluminum passage into a single clause: "Aluminum, an abundant metal with many uses, comes from bauxite, a clay-like ore." That clause is 13 words long, but the average for skilled adults was still more, over 15 words. The average fourth grader would have taken six T-units to say the same thing.

V. FINDINGS: SYNTACTIC CHANGES ON
EACH INPUT SENTENCE

The present chapter lists the syntactic changes actually made by successively older grades of students and by skilled adults in rewriting the Aluminum passage. It also enumerates the structures produced by those transformations which reduced an input sentence to less than a predicate (these have been totaled already, but not enumerated). As has been seen, this is where syntactic growth seems to be most active, most productive, and most far-reaching.

In preparation for this enumeration, each change made on each input sentence by each writer was recorded. The number of these changes made by the 275 writers on the 32 input sentences was about 9,000. If they had proved to be too heterogeneous, the tabulation would have become a meaningless confusion. But they were not that heterogeneous. Instead, it will be seen that a general growth pattern does emerge and that this pattern is confirmed grade after grade and sentence after sentence. Nearly every input sentence has some power to discriminate between levels of maturity, as do individual items on a successful test. Sometimes a single sentence discriminates in several ways.

Before describing the reductions to less than a predicate, however, a few more general observations should be made about other syntactic changes: the selection of main clauses, the retention of subordinate clauses, and coordination.

In *Syntactic Structures,* more than a decade ago, Chomsky used the term "kernel" to describe the string underlying a sentence to which no optional transformations had been applied. Since that time, generative-transformational syntax has been greatly extended, and the term "kernel" no longer appears in the new advanced research. But the term has been picked up in school textbooks and, as a result, has gained wide currency among English teachers.

The term will be particularly convenient to use in the following pages. It is no accident that all of the 32 sentences in the original Aluminum passage are kernels or, more accurately, are from kernel strings. After all, the chief purpose of the experiment was to see what optional "sentence-

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combining" transformations would be used by students of different ages, so it was natural enough to have all rewriters start from scratch.

But the particular convenience in the term for this discussion is that it can be used to describe all of the input sentences. The other syntactic terms, such as "clause," "sentence," etc., can then be reserved for the structures of the output sentences. Thus, in the following pages, "kernel" will be reserved for the input sentences. Each will be numbered successively: K1, K2, etc.

Choice of Main Clauses

In choosing which kernels to retain as main clauses the writers were clearly guided by something other than chance. Chance might allow one kernel to be chosen especially often by one grade, but when the same kernels are so chosen by the next grade, and the next, and the next, and the next, then it becomes quite clear that chance alone does not operate. Instead, those kernels must possess some quality in the discourse as a whole which leads them to be chosen.

Among fourth graders, virtually no choice appeared. Of the 32 kernels, 31 were retained as main clauses by a majority of these beginners. But sixth graders began to be selective: only 16 out of 32 were retained as main clauses by a majority. And, 2 years later, of the nine retained as main clauses by a majority of eighth graders, each one was chosen from the 16 already chosen by the younger grade. If chance alone had operated, it would have been just as likely for all nine to be chosen from the 16 *not* chosen by the younger grade. The consensus becomes still sharper 2 years later. Of the eight chosen by a majority of tenth graders, every one was from the nine chosen by eighth graders. Of the seven chosen by a majority of twelfth graders, six were from the eight chosen by tenth graders. A change by one writer out of 50 would have put that seventh back into the list, too, making the record perfect.

That is not all. If we ask which input kernels were chosen as main clauses by twice as may skilled adults as chose the average kernel for that distinction, we find that six of their chosen seven were from those seven already chosen by twelfth graders, and from those eight already chosen by tenth graders, and from the nine already chosen by eighth graders. The schoolchildren must have been headed in the right direction.

During those 8 school years, the process of selection of main clauses became sharper: it proceeded from 31 to 16 to 9 to 8 to 7 with all but perfect consensus. As schoolchildren mature, they gain a stronger and sharper sense of which clauses deserve the status of main.

What the quality is that accounts for these choices—and they are choices, not chance—composition teachers have always tried to describe to their students. That quality is whatever is possessed in common by the following nine kernels, all of which were chosen by a majority of eighth graders. This nine also includes the eight chosen by tenth graders and six of the

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seven chosen by twelfth graders and by skilled adults. K1: Aluminum is a metal. K2: It comes from bauxite. K9: Workmen extract (these) other substances from the bauxite. K10: They grind the bauxite. K13: The other substances form a mass. K17: They (the workmen) put it (the liquid) through several other processes. K22: It (the chemical alumina) is a mixture. K25: Workmen separate the aluminum from the oxygen. K27: They finally produce a metal.

In contrast, the following nine kernels lack that quality in the whole context—at least they were the ones least often retained as main clauses by tenth graders and twelfth graders. K2: It (aluminum or the metal) is abundant. K3: It has many uses. K6: Bauxite looks like clay. K12: Pressure is in the tanks. K19: The chemical is powdery. K20: It is white. K24: It contains oxygen. K29: It has a luster. K30: The luster is bright.

Growth in Subordinate Clauses

The earlier section on the subordinate clause index has already asserted that as children get older they tend to reduce a larger proportion of main clauses to subordinate clauses, but the increase tapers off in the later grades. On this instrument it flattens out at the eighth grade, whereas in writing that is not controlled as to subject matter (Hunt 1965) it flattens out later, somewhere near the twelfth grade. In either case, skilled adults produce only slightly more subordinate clauses per main clause, if any more, than older schoolchildren. It is not in this respect that their syntactic superiority lies.

A second general observation about subordinate clauses has also been made (Hunt 1965). In general, it appears that, of the three kinds of subordinate clauses, the number of adjective clauses is least dependent on subject matter and most dependent on maturity, that the number of adverb clauses is intermediately dependent on subject matter and intermediately dependent on maturity. That noun clauses are most dependent on subject matter and least dependent on maturity is certainly true when the writing sample includes direct discourse and indirect discourse and when what is thought or said is called a noun clause.

The present experiment lends some support to this generalization about the three kinds. For instance, in rewriting these 9,000 kernels and producing several hundred subordinate clauses, no schoolchild and no skilled adult produced a single noun clause. To suppose they were incapable of producing noun clauses or that this failure was the result of chance is impossible. Surely it can only be that the subject matter, as expressed in these kernels, was not conducive to the production of noun clauses, or, more accurately, that none of the strings underlying these kernels happened to be the kind that underlies a noun clause.

Furthermore, the number of adverb clauses here was only a sixth as great as the number of adjective clauses. This is nowhere near the usual

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proportion. Usually the proportion in longer writings and on a variety of subjects (Hunt 1965) is closer to 1 to 1 rather than 1 to 6. This unusual proportion is surely a function of the subject matter or, more accurately, of the kernels expressing the subject matter.

There can be no doubt that a passage similar to this one could be devised which would elicit noun clauses, but it is not at all certain that a connected discourse of 100 words or more, expressed in kernels, could be devised which would fail to elicit adjective clauses, at least from older writers. A passage which failed to elicit adjective clauses would probably fail also to be connected discourse.

That this passage was especially congenial to the formulation of adjective clauses will be obvious to anyone who notices the great amount of repetition of nouns—or of pronouns. But if he thinks this passage is abnormal in that respect, it is simply because he has spent very little time breaking ordinary skilled adult prose down into the kernel strings that underlie it.

Movable adverb clauses were formed much less often than adjective clauses, only a sixth as often. The number produced did tend to increase with maturity, though not after grade 10: 4, 8, 25, 34, 28. It is interesting that the 25 skilled adults produced 14, exactly the same proportion as were produced by the 50 twelfth graders.

Those kernels out of which adverb clauses were most frequently formed were those in the middle of the passage, where the successive steps in the manufacturing process were being described. Perhaps to reassure the reader that they were indeed sequential steps in a larger process, writers introduced adverbial subordinators. The commonest subordinators were *until* (41 occurrences), *when* (14), *where* (13), *after* (9). These kernels, which were transformed to adverb clauses at least twice as often as the average kernel, were K13 (transformed into an adverb clause 14 times by 250 writers), K14 (7 times), K16 (11 times), K17 (9 times), and K18 (38 times). It should be noticed that only one kernel is missing from the otherwise unbroken sequence listed above. K15 became an adverb clause only two times for reasons obvious later. It is also interesting that one of those kernels happened to be transformed into an adverb clause 12 times as often as the average. In fact, this one kernel alone, K18, accounts for more than a third of all occurrences of adverb clauses. It expresses the last of the manufacturing steps, and the input kernel is already marked with *finally*, the only adverb to appear in the whole original passage: *It finally yields a chemical.* Students from all grades, but especially the older grades, added a subordinator: the frequency by grade was 1, 3, 10, 11, 13. And almost always (34 times out of 38) the subordinator was *until*, so the passage usually read ". . . until finally it yields . . ." It is this one usage which makes *until* more common than any other adverbial subordinator.

With almost as great frequency as adverbial subordinators (89 compared with 99), certain other words indicating sequential relations were also used. By far the commonest was *then* (72 occurrences in 9 kernels). Usually

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these words introduced full clauses, though, occasionally, reduced clauses. It is possible that such relational words, though they do not subordinate clauses, accomplish much the same purpose as words which do and are just as indicative of maturity. If so, then in studies of syntactic development both should be taken into account. It is entirely possible, since the T-unit takes into account the presence of adverb clauses but not clauses introduced by these other relational words, that a unit other than the T-unit would be a more accurate measure of syntactic maturity, even if not so conveniently related arithmetically to clause length and sentence length.

Growth in Coordination

It has already been shown that beginning writers coordinate two or more full main clauses, or, more accurately, they coordinate T-units, more often than older students. Almost always they use *and*. The number of such coordinations per main clause declines sharply, from .74 to .34 to .25 to .13 to .08. Fourth graders use nine to 10 times as many as twelfth graders. Between grades 4 and 6 the frequency is cut almost in half. This immature device for grouping certain ideas together into larger constituents is outgrown and left behind as other devices are added to their repertoire.

To a very slight extent the immature device is replaced by the coordination of full predicates as writers come to see still more clearly that one of two identical subjects can be deleted. That is, there is an increase of about 20 percent from grades 4 to 6, but the number of coordinated predicates is already high in the fourth grade, and the increase is not impressive. The number from grade to grade is 93, 111, 112, 101, 98, a moderate rise and an almost comparable decline.

But there are many, many other ways to form kernels into larger constituents, and no doubt all those other more mature ways help to displace the immature way.

A certain amount of consensus from grade to grade did occur upon which kernels were most likely to have subjects deleted, leaving coordinated predicates. Taking five writers per grade—one out of 10—as the cutoff, it happens that each of the five grades chose seven kernels. Three kernels (K3, K11, K29) were chosen by all five grades. Four (K6, K10, K18, K32) were chosen by three grades. Six (K2, K4, K7, K8, K17, K24) were chosen by one grade. Six kernels of the 32 were never reduced to a coordinated predicate by any student. Those on which consensus was strong will be mentioned again in the kernel-by-kernel analysis.

Certain kernels contained not only identical subjects but identical verbs as well, differing only in the objects of the two verbs. Examples are K7 and K8: *Bauxite contains aluminum,* and *It* (bauxite) *contains several other substances.* Other examples are K23 and K24: *It contains aluminum,* and *It contains oxygen.* In the first of these pairs, one was reduced to a coordinated object with this frequency: 14, 28, 29, 34, 31 times. For the second

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pair the score was 16, 51, 53, 59, 59. The total of the two sets of scores is 30, 79, 82, 93, 90. In both pairs there is a sharp increase between grades 4 and 6 and after that almost none. Only a fifth of the fourth graders accomplished this reduction, whereas four-fifths of all older students did. So this is something else that students learn early.

With respect to coordination, then, there is this fairly clear hierachy: the coordination of full main clauses declines throughout the school years with a decline of about 50 percent from grades 4 to 6. During that same 2-year period the deletion of identical subjects and the coordination of full predicates increases about 20 percent, but this is not a major change. The major change in coordination is the further deletion of identical verbs along with identical subjects; this practice increases fourfold. But coordination seems to be learned relatively early so far as the evidence of this experiment is concerned.

The input kernels provide no opportunity for certain other deletions and coordinations. For instance, in ordinary prose it is common for subjects to be coordinated when the full predicates are identical: *John and I went home*. But no such pair of kernels was provided as input, so no coordinated subjects happen to occur in this experiment.

Certain other constructions might be considered to involve coordination, such as *white, powdery chemical*. This could be supposed to have gone through the intermediate stage *the chemical was white and powdery*. But there is no need to suppose so, and this kind of construction, like the appositive, will not be treated as coordinate.

So growth in coordination seems to occur early and does not contribute much to full maturity.

Syntactic Changes Sentence by Sentence and Grade by Grade

In the following pages attention will be focused on those changes which the writers made in reducing each input kernel to something less than a predicate, embedding the result in some other kernel. The total number of such embeddings per grade and per group within grade has already been shown to discriminate significantly among successively older grades—chronological maturity—and also among groups within grade—mental ability or academic achievement. The number of such reductions has also been shown to correlate highly with words per clause.

Generally speaking, kernel sentences—kernel strings—are relatively short compared with actual sentences. It is certainly plausible to suppose that the length of base or kernel strings generated by beginning writers is not perceptibly different from the length of those generated by mature writers. It is certainly plausible also to suppose that the more mature writer's greater syntactic complexity lies in his more complex employment of the recursive possibilities of language, in his more complex employment of embedment rules. In fact, this whole experiment indicates that this plausible

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supposition is indeed an empirical fact. The experiment keeps constant for all writers the output of the phrase structure rules, the base component. But it allows each writer to choose freely the recursive embedment rules he wants to apply.

The conclusion which has already been drawn and will be demonstrated now by instance after instance is that linguistic maturity consists chiefly in the ability to make many embedments per clause. That this can be done excessively and ineptly is indeed true but irrelevant to this study.

In the following pages, attention will be paid first to the schoolchildren and second to the skilled adults. It is important to remember that the number of skilled adults was only 25, just half the number of students in each grade. So if skilled adults did something seven times and a given grade of students did it 14 times the frequency of the event is exactly the same per individual in the two groups. Consequently, in tabulating the actual number of events among skilled adults, twice that number of events will sometimes also be given in parentheses immediately afterward to facilitate comparison with the groups of 50 writers.

The question to bear in mind in looking to skilled adults is whether the schoolchildren manifest a tendency shown also, or carried still further, by the skilled adults, indicating that the schoolchildren are headed in the right direction, or whether, instead, the skilled adults are radically different, suggesting that the schoolchildren may be headed in the wrong direction—that the direction of their change is not toward syntactic maturity.

Table 10 summarizes the changes made in each input sentence by each grade. These changes and certain others are discussed in the pages that follow.

K1: Aluminum is a metal. K2: It (aluminum or the metal) is abundant. K3: It (aluminum or the metal) has many uses.—Of the 250 students writing, 240 chose to retain K1 as a main clause. But the older students usually reduced K2 and K3 to less than a full predicate, embedding it in that main clause. As will be seen, the older the writer the more likely he was to make such a reduction.

No reduction for K1 was common, but nonetheless seven older students did delete all but the two nouns, writing them in apposition inside some other kernel: *aluminum, a metal* or *metal, aluminum.*

The adjective from K2 was usually embedded before the noun in K1 (*abundant metal*). From K3 the predicate *has many uses* was transformed either to a prepositional phrase, usually *with many uses* or to an adjective by adding the suffix *ful* to the noun stem (*useful*). These remnants of K3 and K2 were usually embedded in K1, producing *Aluminum is a useful and abundant metal,* or *Aluminum is an abundant metal with many uses.*

The frequency of these and other reductions to less than a predicate increased at every grade interval, from a total of 5, then to 17, then to 56, then to 66, strongly indicative of maturity.

The skilled adults carry the same trends still further: They retain K1

TABLE 10

SUMMARY OF CHANGES TO LESS THAN A PREDICATE

Input	G4	G6	G8	G10	G12	Skilled Adults
K1:						
appositive.............	0	0	1	5	4	7 (14)
K2:						
prenom. adj...........	5	13	29	39	36	20 (40)
K3:						
prep. phrase..........	0	4	7	6	18	8 (16)
prenom. adj...........	0	0	3	6	8	10 (20)
having, etc.............	0	0	0	1	1	0
Subtotals...........	5	17	40	56	66	45 (90)
K4:						
miscellaneous..........	0	0	1	1	1	2 (4)
K5:						
appositive.............	1	6	18	20	15	16 (32)
called bauxite...........	0	4	9	17	15	9 (18)
known as bauxite........	0	0	0	2	1	0
Subtotals...........	1	10	28	40	32	27 (54)
K6:						
clay-like...............	1	1	3	7	10	12 (24)
clay-looking............	0	1	0	1	1	0
clayish.................	0	0	0	0	1	0
clayish-looking..........	0	0	0	0	1	0
clay-colored............	0	0	0	0	1	0
looking like, etc.........	0	0	0	1	0	0
resembling, etc..........	0	0	0	1	0	0
Subtotals...........	1	2	3	10	14	12 (24)
K7:						
coord. object..........	0	0	1	11	10	2 (4)
containing..............	0	0	1	0	0	0
K8:						
coord. object..........	14	28	27	23	20	2 (4)
miscellaneous..........	0	0	0	0	1	2 (4)
Subtotals...........	14	28	29	34	31	6 (12)
K9:						
to V..................	0	1	3	4	6	5 (10)
in order to V...........	0	0	0	0	2	0
miscellaneous..........	0	0	0	1	1	4 (8)
Subtotals...........	0	1	3	5	9	9 (18)
K10:						
by V *ing* or						
and V *ing*.............	0	2	18	7	9	3 (6)
miscellaneous..........	0	0	0	3	1	0
K11:						
by V *ing* or *and* V *ing*....	0	2	14	5	9	3 (6)
past participial modifier..	0	0	0	0	1	4 (8)
miscellaneous..........	1	0	0	1	1	1 (2)
Subtotals...........	1	4	32	16	21	11 (22)

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TABLE 10—*Continued*

Input	G4	G6	G8	G10	G12	Skilled Adults
K12:						
pressure tanks...........	3	9	22	15	16	5 (10)
miscellaneous............	2	9	6	24	27	19 (38)
Subtotals.............	5	18	28	39	43	24 (48)
K13:						
to V, etc...............	0	2	2	8	7	0
miscellaneous...........	0	0	0	0	0	4 (8)
Subtotals.............	0	2	2	8	7	4 (8)
K14 and K15:						
to V...................	1	4	7	3	2	1 (2)
filter the mass or *is filtered*.	0	0	2	2	4	10 (20)
by filters...............	0	3	10	6	10	0
by using filters..........	1	3	5	4	6	0
other prep. phrases.......	3	13	5	4	3	1 (2)
miscellaneous............	4	3	4	15	10	17 (34)
Subtotals.............	6	26	35	34	35	29 (58)
K16:						
V *ing*..................	0	0	1	3	5	7 (14)
miscellaneous...........	0	1	3	4	11	6 (12)
K17:						
miscellaneous...........	1	0	3	8	10	8 (16)
Subtotals.............	1	1	7	15	26	21 (42)
K18:						
miscellaneous...........	0	0	1	2	3	8 (16)
Subtotals.............	0	0	1	2	3	8 (16)
K19:						
prenom. adj.............	1	17	30	36	42	22 (44)
coord. pred. adj..........	1	3	3	1	1	0
miscellaneous...........	0	0	0	3	0	2 (4)
K20:						
coord. pred. adj..........	8	15	10	4	2	0
prenom. adj.............	0	9	23	37	41	23 (46)
Subtotals.............	10	43	66	81	86	47 (94)
K21:						
appositive...............	0	2	7	6	9	10 (20)
called..................	0	5	9	20	23	13 (26)
known as...............	0	0	0	0	1	0
Subtotals.............	0	7	16	26	33	23 (46)
K22:						
appositive...............	1	2	10	7	8	14 (28)
Subtotals.............	1	2	10	7	8	14 (28)

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TABLE 10—*Continued*

Input	G4	G6	G8	G10	G12	Skilled Adults
K23 and K24:						
coord. obj..............	8	36	38	35	35	13 (26)
V *ing*..................	0	0	4	6	8	5 (10)
prep. phrase with coord.						
obj...................	8	15	15	24	24	19 (38)
miscellaneous...........	0	0	0	2	3	6 (12)
Subtotals.............	16	51	57	67	70	43 (86)
K25:						
to V....................	3	6	7	10	4	4 (8)
in order to V............	0	0	0	0	1	0
by V *ing*................	0	0	1	1	0	0
V *ing*...................	0	0	0	0	1	0
miscellaneous...........	0	0	0	0	0	1 (2)
K26:						
miscellaneous...........	4	14	32	39	40	22 (44)
Subtotals.............	7	20	40	50	46	27 (54)
K27:						
to V....................	1	3	0	1	3	5 (10)
V *ing*..................	0	0	1	2	3	2 (4)
miscellaneous...........	0	0	0	5	2	1 (2)
Subtotals.............	1	3	1	8	8	8 (16)
K28:						
prenom. adj.............	2	8	19	24	28	20 (40)
miscellaneous...........	1	0	0	3	2	2 (4)
Subtotals.............	3	8	19	27	30	22 (44)
K29:						
prep. phrase.............	1	4	6	11	10	7 (14)
prenom. adj.............	0	1	4	2	3	4 (8)
miscellaneous...........	0	0	0	1	6	5 (10)
Subtotals.............	1	5	10	14	19	16 (32)
K30:						
prenom. adj.............	2	11	21	35	32	17 (34)
coord. pred. adj..........	0	4	0	0	0	2 (4)
Subtotals.............	2	15	21	35	32	19 (38)
K31:						
prenom. adj.............	3	9	21	38	42	23 (46)
coord. pred. adj..........	5	20	10	0	2	0
Subtotals.............	8	29	31	38	44	23 (46)
K32:						
miscellaneous...........	0	0	2	0	0	5 (10)
Subtotals.............	0	0	2	0	0	5 (10)
Total for each grade..	83	292	481	611	663	443 (886)

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as a main clause (17 out of 25), or they reduce it to an appositive (7). K2 they reduce to a prenominal adjective (16), or some other structure less than a predicate (4). K3 they reduce to the adjective alone (8), or a prepositional phrase (8), or something else (2).

Thus, these 25 writers reduce these three kernels to less than a predicate on 45 occasions, more often per person than even the oldest grades of schoolchildren.

K4: *It (aluminum) comes from bauxite. K5: Bauxite is an ore.*—Three-fourths of all students retained K4 as a main clause. Almost no one (only three) reduced it to less than a predicate.

But K5 was reduced to less than a predicate by a majority of students in each of the three upper grades.

From K5 both the subject and copula verb were deleted, leaving only the predicate noun, *an ore*, written as an appositive. Usually this appositive was attached to *bauxite* in the previous sentence, K4. Thus, *It comes from bauxite, an ore* was common (30 occurrences) or . . . *from bauxite ore* (3 occurrences).

Many students changed the sequence of the two nouns, so that instead of the strange name *bauxite* coming before the familiar word *ore* the familiar word came first and the less familiar word came afterward. Thus they wrote, slightly altering the original main clause to do so, *It comes from an ore, bauxite*. Still others, instead of writing the two nouns in apposition, inserted the explanatory *called* (45 occurrences), thus producing . . . *an ore called bauxite*. Instead of *called*, three students inserted *known as*, thus producing . . . *an ore known as bauxite*. The insertion of *called* or *known as* provides warning to the reader that a strange name will be introduced and again puts the familiar word *ore* first.

That these various ways of reducing K5 to less than a predicate are strongly indicative of maturity is clear from the steady increase of occurrences across three of the four intervals between grades: 1, 10, 27, 39, 31.

Skilled adults carried still further this tendency to reduce K5 to less than a predicate. Every one of them did so. Of the 25, nine used the *called* construction, and 16 used the appositive.

K6: *Bauxite looks like clay.*—K6 was reduced to less than a predicate by about a fifth of the students in the two upper grades (by 22 out of 100). The frequency of such reduction moved steadily upward at every grade level, indicating unmistakably a relation to maturity. Note that such reduction was very infrequent—almost nonexistent—in the first three grades: 1, 2, 3, 10, 14.

The older writer's problem, as he saw it, was to transform the predicate noun *clay* into some kind of prenominal modifier of the former subject of the kernel: *bauxite*. Once that solution was achieved, the modifier could be embedded into any of the surrounding kernels that retained the word *bauxite*.

One solution was to add *ish*, producing *clayish* (1 occurrence). Other

solutions retained the stems *look* and *clay* from the original kernel and added one or more affixes to produce *clayish-looking* (1 occurrence), *clay-looking* (3 occurrences). *Clay-colored* also occurred once. The commonest solution (22 occurrences) was to retain *like* from the original kernel (*clay like*) as if the underlying kernel were equivalent to *Bauxite looks to be like clay*.

Two other solutions involved the addition of *-ing* to the verb to make it a present participial modifier of *bauxite: looking very much like clay* (or *resembling clay*).

Half the skilled adults (13) retained this kernel as an adjective clause, often with remnants of other kernels embedded in it. The other half (12) reduced it to *clay-like*. Thus, skilled adults carried further than any grade of schoolchildren the tendency to reduce this to less than a predicate.

K7: Bauxite contains aluminum. K8: It (bauxite) contains several other substances.—This pair of kernels, with identical subjects and identical verbs, provided an obvious opportunity to coordinate the direct objects, deleting one of the subjects and one of the verbs. More than half the writers in the older four grades made that transformation. But only about a quarter of fourth graders did, so the reduction to less than a predicate is clearly indicative of maturity.

Usually the conjoiner was *and* (*. . . contains aluminum and several other substances*) (98 occurrences). Once in a while a different conjoiner was used: *along with* (4), *with* (2), *as well as* (3), *plus* (3), and others to be mentioned below.

But some students perceived an additional problem besides the opportunity for deletion and conjoining. Apparently they were aware that an earlier kernel saying that *Aluminum comes from bauxite* already had entailed one of these kernels: that *Bauxite contains aluminum*. So they took cognizance of that fact and chose a conjoiner which, in effect, says, "You, the reader, already know that bauxite contains aluminum. I have told you that. What I have new to tell you in this sentence is that it also contains several other substances." So a few students reversed the order of the conjoined elements and used a subordinator *besides aluminum* (17), *along with aluminum* (2), *other than aluminum* (3), always subordinating what had previously been mentioned. What is pertinent to this study is that these particular changes were made predominantly by the older students: 0, 0, 1, 11, 10.

To accommodate that same entailment, one tenth grader used multiple conjoiners *not only . . . but . . . as well*. These conjoiners have the additional psychological effect of preparing the reader for the relation between the conjoined elements even before the reader's eye catches the first of the two. A twelfth grader used a still more elaborate transformation to prepare the reader as early as the beginning of the sentence: *Not only does bauxite contain aluminum but several other substances too*. The point here is that only older students did this.

The number of reductions to less than a predicate—and these occur whenever one direct object is conjoined with the other—increased with

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maturity across three of the four intervals between grades: 14, 28, 29, 34, 31.

In the section on the Not Analyzed category it was noted that when an input kernel failed to appear in the output of a writer there was no sure way to tell whether the writer omitted it intentionally or inadvertently. However, in this case there may be evidence that omission was intentional. It has already been pointed out that K7, saying that bauxite contains aluminum, adds no new information to K4, which says that aluminum comes from bauxite. One kernel entails the other. And it is a fact that, out of the 25 skilled adults, 19 omitted this entailed kernel (K7), more than twice as many as omitted any other kernel, and six times as many as omitted the average kernel. So there is reason to consider the omission of K7 as intentional and as a mark of maturity.

If omission of K7 is, on that evidence, a mark of maturity, then it would be interesting to see how often it was omitted by each grade of schoolchildren. The number is larger for the older grades, though it does not increase across all grade intervals. The number of omissions is 4, 5, 16, 13, 14. For the two younger grades the total is nine, for the two older 27, though the score for eighth graders is highest of all.

Similarly, K8 is almost as clearly entailed by the kernel to follow, K9. At least if bauxite did not contain other substances, then it would not be possible, as it is said in K9, for the other substances to be removed from the bauxite. Again we find the entailed sentence omitted by skilled adults four times as often as is usual for a kernel: 11 out of 25 did so. And again we find that the number of schoolchildren who omitted this particular kernel increases with age: 2, 2, 4, 11, 9.

This is one occasion when we cannot say that skilled adults reduced these two kernels to less than a predicate more often than schoolchildren did. Instead, they omitted them, and there is evidence that they may have done so because the two were completely redundant with other kernels. Only four skilled adults coordinated these two direct objects.

K9: Workmen extract these other substances from the bauxite.—In this one kernel is expressed the purpose of the manufacturing process which is sketched in the next 10 or so kernels. A few of the more mature students recognized that purposive relation and reduced this kernel to a purposive infinitival: *to extract* (14), *in order to extract* (2). The frequency of this transformation from each grade was 0, 1, 3, 4, 8, clearly increasing with maturity. A fifth of the skilled adults used it too, a still larger proportion.

This reduction and many of those that were used in the next kernels accomplish something more than has been mentioned so far. They in fact make explicit a meaning which was not explicit in the original kernels. By using a purposive construction they have made explicit the relation between the meaning of this kernel and the meaning of other kernels. It can hardly be said that this purposive relationship was implied by any one kernel itself, nor even by the set of kernels as a whole, except as the reader brings to

the whole discourse his mature knowledge of the sociophysical world. It is that knowledge which tells him of the purposive relation, and his syntax allows him to express it.

Though the great majority of the syntactic changes that increase with maturity are those that reduce a clause to less than a clause (and less than a predicate), one change which does not do so is also a mark of maturity in this particular experiment. It is the passive with agent deleted.

One stylistic result of this transformation is that what originally stood as subject of the sentence in its active form no longer survives in the passive. For instance, this kernel, so transformed, deletes *workmen* and retains *These other substances are extracted from the bauxite. Workmen* happens to be the subject of this kernel and eight more to follow. Yet an adult's knowledge of the world tells him that in explaining a modern manufacturing process it is important to tell what is done, but not especially important to say that workmen happen to be engaged in the process. So *workmen*, though subject of nine kernels, is unimportant. One way to delete it is to use the passive. Other ways, of course, are to use those many other sentence-embedding transformations which reduce the clause to a predicate or less by deleting the subject.

In any event, the passive with agent deletion was used more frequently on this kernel by older writers: 1, 0, 0, 3, 11. In those following kernels with *workmen* as subject we find clearly confirming evidence that this syntactic change increases with maturity (table 11).

The kernels without *workmen* as subject were passivized much less often. Though there were 23 of the others, as compared with only nine of these (2.5 times as many), the others were passivized only 14 times whereas these were 231 times.

This kernel was also one of those retained with special frequency as a main clause. About half the students in each of the three older grades did so (G8, 27; G10, 29; G12, 25). Often remnants of the following kernels were embedded in it.

TABLE 11

NUMBER OF PASSIVIZATIONS

	G4	G6	G8	G10	G12
K9..............	1	0	0	3	11
K10.............	0	1	0	8	8
K11.............	0	0	1	2	0
K14.............	0	3	5	25	30
K15.............	0	1	2	9	12
K17.............	1	6	12	21	20
K25.............	0	1	3	7	13
K26.............	0	0	1	3	3
K27.............	0	0	3	6	9
Total..........	2	12	27	84	106

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Only one-fourth (6) of the skilled adults retained this as a main clause. Seven of them omitted it.

K10: They (workmen) grind the bauxite. K11: They (workmen) put it (bauxite) in tanks.—Older students usually coordinated these two kernels, reducing at least one of them to less than a full clause. Often one was left as a full clause and the second was reduced to a coordinated predicate; some of these times both were left in the active form, *they grind it and put it in tanks,* and sometimes both were passivized with the agent deleted, *it is ground and put in tanks.* When the two predicates were passivized and coordinated, the form of *be* was always deleted from the second.

The frequency of such full clauses with one coordinated predicate does not increase past the sixth-grade level, however: 20, 33, 25, 31, 31. Skilled adults used this construction about as often as the older students did (16 times).

Somewhat greater maturity was shown by reductions to less than a predicate. For instance, just as the kernel previously discussed was reduced to a purposive expression, so the two of these were reduced to a coordinated expression of means embedded in some third kernel: *by grinding . . . and putting . . . in tanks.* The number of such reductions of the two kernels was 0, 4, 32, 12, 18. Here the eighth grade is very high; otherwise, there is a steady increase. Skilled adults used this reduction less often than the older students, much less often than eighth graders: six times. It should be remarked that this relation of means toward some other end was not stated explicitly by any kernel.

Only one student used *ground bauxite.* He was a twelfth grader, as we might, by now, expect. Four skilled adults used it.

As these figures have indicated, the eighth graders used more of those structures which we would ordinarily call marks of maturity than any other grade of students—even than skilled adults. But that fact must not be misinterpreted: A writer tended either to convert K9 to a purposive or K10 and K11 to a coordinated expression of means; that is, he wrote either *to extract . . . they grind . . . and put . . .* or *they extract . . . by grinding . . . and putting. . . .* A writer does not convert both. So the eighth grader's preeminence here is partly counteracted by his lack of preeminence with the previous kernel, K9.

K12: Pressure is in the tanks.—Whether or not this kernel is fully grammatical, older students felt overwhelmingly that somehow it must be reduced to less than a predicate and must be combined with *tanks* in the previous kernel. The number in each grade who reduced it is 5, 18, 28, 39, 43, clearly indicating developmental significance.

The commonest of these forms was *pressure tanks* (3, 9, 22, 15, 16). Next commonest was *pressurized tanks* (0, 3, 3, 11, 18). Other forms were *pressured tanks* (0, 3, 1, 4, 1), *pressurizing tanks* (1), *pressure in the tanks* (6), *filled with pressure* (2), *pressure-filled tanks* (2), *tanks full of pressure*

(2), *tanks with pressure in them* (2), *tanks with pressure* (5), *tanks under pressure* (3), *tanks of pressure* (1), *tanks containing pressure* (1).

Skilled adults reduced the kernel to less than a clause unanimously. Like the older students, they preferred *pressure tanks* (5) or *pressurized tanks* (8). They also used *tanks under pressure* (6) and three other forms. So skilled adults carried a little further the same tendencies to reduction that were shown by the older students.

K13: The other substances form a mass.—More than half of the students even in the older grades retained K13 as a main clause: 40, 40, 38, 30, 29.

There were very few changes which could, even by stretching, be categorized as reductions to less than a predicate or less than a clause: 0, 2, 2, 8, 7. All such changes involved insertion of a causative verb such as *cause, make,* or *force,* with *pressure* (or *pressure tanks*) as subject: for instance, *pressure causes the substances to form a mass.*

K14: They (workmen) remove the mass. K15: They (workmen) use filters.—An unusually large number of students retained K14 as an adjective clause attached to K13, but everyone who did so first passivized the adjective clause (1, 6, 16, 19, 18). Thus they wrote something like *The other substances form a mass which is removed* (or *filtered*), etc.

For K14 and K15, students used a wide variety of further reductions. Students of all grades occasionally combined the two predicates by reducing the first to a purposive infinitival, *use filters to remove the mass.* The frequency for each grade was 1, 4, 7, 3, 2, suggesting an early but not a late developmental trend.

A few of the older students preferred a further reduction. Knowing that the verb *filter* means to "remove something using a filter," they converted the noun *filter* into the verb *filter* (or *filter off,* or *filter out*) and wrote *filter the mass.* Or, using the passive, they wrote *the mass is filtered.* The frequency by grade was 0, 0, 2, 2, 4, suggesting late development. More than half (14) of the skilled adults used this reduction, carrying the trend very much further.

A third solution, which implies that a filter is the agent for the removal, reduced the predicate *use filters* to *by filters.* The frequency by grade was 0, 3, 10, 6, 10.

Another solution replaced the finite verb *use* with that stem plus *-ing,* adding *by: by using filters.* The frequency by grade was 2, 3, 5, 4, 6, suggesting a slight developmental trend.

Another solution, which again reduced to less than a predicate, replaced the verb with a preposition, forming an agentive: *with filters.* The frequency was 3, 13, 5, 4, 3, with a decided peak at the sixth grade.

Other reductions to less than a predicate occurred infrequently: *by filtration process* (1 time), *by filterization process* (2), *by filtering process* (1), *by the use of filters* (11), *with the use of filters* (2), *through the use of filters* (1), *by filtering* (6), *using filters* (4), *into a filter* (1), *through filters* (1), *after filtering* (2).

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When all these various ways which reduced one kernel to less than a predicate are added together, they produce evidence of early maturity: 6, 26, 35, 34, 35.

Each of the skilled adults reduced at least one of these kernels to less than a predicate, using expressions used also by the students, and thus carrying the same developmental tendency much further.

K16: *A liquid remains. K17: They (the workmen) put it (the liquid) through several other processes.*—A clear developmental trend is indicated by the tendency of older students to reduce K16 to less than a predicate (0, 1, 4, 7, 16). Either they added *-ing* to the verb stem, forming a prenominal modifier *the remaining liquid* (0, 0, 1, 3, 5), usually incorporating it into the following kernel, or they changed the verb into *leaving a liquid* (0, 0, 3, 2, 8). Seven skilled adults used *remaining liquid,* one used *the remainder,* and one *the filtrate,* so they carried the trend still further.

The second of the kernels also shows a clear developmental trend in the frequency of reductions to less than a predicate (0, 0, 3, 8, 10). The verb *put through* (or synonyms, which allow the deletion of *workmen*) was given an *-ing* ending and was usually preceded by *after: after putting it through* (4), *after being put through* (3), *after undergoing* (1), *after more processing* (1), *after being processed* (1). Other reductions were *after several other processes* (6), *through several other processes* (4).

The total of these for both kernels indicates a very strong developmental trend: 0, 1, 7, 15, 26.

K18: *Finally it (the liquid) yields a chemical.*—This kernel was seldom reduced to less than a predicate, though in the two older grades about half the students reduced it to a subordinate clause, often an adverbial clause introduced by *until* (27 for all grades), *till* (6), *where* (1), *when* (1).

The full predicate was coordinated, after deletion of the subject, thus reducing it to less than a clause, with this frequency: 0, 3, 5, 5, 5.

The few reductions to less than a predicate were these: *finally yielding a chemical* (3), *finally becoming a chemical* (1), *to obtain the desired chemical* (1), *in order to arrive at the desired chemical* (1). The total of these by grade was 0, 0, 1, 2, 3. Two skilled adults reduced it to *yielding* and *leaving.*

Skilled adults, like older students, kept this as a clause, embedding many of the remnants of the following kernels in it. Nine kept it as main, six as subordinate (4 adjectival, 2 adverbial), just about the way the older students did.

K19: *The chemical is powdery. K20: It (the chemical) is white. K21: It (the chemical) is alumina. K22: It (the chemical alumina) is a mixture. K23: It (the chemical mixture alumina) contains aluminum. K24: It (the chemical mixture alumina) contains oxygen.*—These six kernels are extremely redundant. The same subject appears in each of the six, the same verb, the copula BE, appears in the first four, and the verb is duplicated in the last two. After the four copulas, the first two have predicate adjectives, the next two have predicate nominals.

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Students in all grades reduced some of these kernels to less than a predicate, but the evidence clearly indicates that the older the student the more of them he was able to reduce in this way, as we shall now see as we examine them individually.

K19: *The chemical is powdery. K20: It (the chemical) is white.*—The predicate adjective *powdery* from K19 became a prenominal modifier with this remarkably significant frequency: 1, 17, 30, 36, 42. In fact, if we consider each of the three groups within each grade we find that there is an increase from low to middle or middle to high at eight of the 10 intervals. The scores were, going from low to middle to high: G4: 0, 0, 1; G6: 3, 5, 9; G8: 8, 11, 11; G10: 8, 12, 16; G12: 12, 13, 17.

A few students used a less mature reduction to less than a predicate. They deleted all of the clause but the adjective, but, instead of moving it to prenominal position, coordinated it with the predicate adjective of the following kernel, producing *The chemical is white and powdery.* The frequency was 1, 3, 3, 1, 1. Older students used the more mature reduction instead.

Three tenth graders changed the predicate adjective to a predicate nominal: *is a white powder.*

Of the 50 twelfth graders, 43 reduced K19 to less than a predicate, and skilled adults did so even more often: 24 out of 25. Of the skilled adults, 22 used the prenominal adjective, favoring it like older students; one used the predicate nominal, like the three tenth graders, and one used the noun *a powder* as an appositive.

Of those who retained the full predicate in K19, a good many of the lower- and middle-grade students nonetheless reduced the following kernel, K20, to only a predicate adjective, coordinating it with the unreduced one, writing *is powdery and white.* The frequency was 8, 15, 10, 4, 2. The number who wrote *is white and powdery* has already been reported. The total of those who retained one of the predicate adjectives but coordinated the other with it was 9, 18, 13, 5, 3, indicating that sixth graders and even eighth graders write this construction more frequently than fourth graders do; and that still older students clearly desert it for a greater reduction as we saw in the previous paragraph and will see again now.

The number who deleted all of K20 but the predicate adjective and moved it to prenominal position in some nearby kernel is strongly indicative of maturity, as it was in the case of the previous kernel. The frequency here is 0, 9, 23, 37, 41. The number who moved to prenominal position the adjective in K19 or K20 (or both) is thus 1, 26, 53, 73, 83, remarkably substantial evidence of development from these two kernels. It is more mature to reduce two kernels than one. All but two of the skilled adults reduced K20 to a prenominal adjective, thus extending still further the trend noted in the paragraph above.

K21: *It (the chemical) is alumina.*—In K21 we find the same sort of thing we did with the earlier predicate nominal sentence, K5, *Bauxite is an ore.* With increasing frequency as they get older, students delete all but the

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noun, writing it as an appositive (0, 2, 7, 6, 9), or they insert *called* before the less familiar word, writing *chemical called alumina* (0, 5, 9, 20, 23). Instead of inserting *called*, one twelfth grader inserted *known as*. So the total of these reductions by grade is 0, 7, 16, 26, 33, again giving substantial evidence of a developmental tendency.

Usually *alumina* was set in apposition to its former subject *chemical* (18), but occasionally to *mixture* (6).

Skilled adults used these same reductions even more often than twelfth graders—23 out of 25, as compared with 33 out of 50; 10 used the appositive, 13 the *called* form.

K22: *It (the chemical alumina) is a mixture.*—This predicate nominal sentence was reduced only to an appositive, and with the following frequency by the various groups: 1, 2, 10, 7, 8; skilled adults, 14.

K23: *It (the chemical mixture alumina) contains aluminum. K24: It (the chemical mixture alumina) contains oxygen.*—These two, with identical subjects and identical verbs but different objects, need to be considered together.

As in the case of K7 and K8, coordination of the two direct objects, after deleting one of the duplicated subjects and one of the duplicated verbs, was clearly indicated to all but the youngest students. Fourth graders, however, failed to see the opportunity for so great a reduction on this occasion just as they failed on several others. Fourth graders tended to delete only a subject, retaining both full predicates—that is, both verbs and their objects. The number of students in each grade who did so is as follows: 13, 3, 3, 2, 1. In contrast to this decrease after grade 4, the number who deleted one duplicate verb, coordinating only the objects, jumps up after grade 4. The number for K23 and K24 together is 8, 36, 38, 35, 35. Here again, we have clear evidence of one transformation, the coordinated full predicate, being replaced by a more mature one.

In addition to deleting one of the duplicated verbs, some older students also reduced to nonfinite status the one of the verbs they did retain. That is, they added *-ing* to the verb stem, writing *containing oxygen and aluminum* (or *aluminum and oxygen*). The frequency of this further reduction was 0, 0, 4, 6, 8. Skilled adults did so about as often: five times.

Other reductions that increased with age by-passed both occurrences of the verb *contains*. Knowing that a mixture contains two or more substances, some students wrote *a mixture of aluminum and oxygen* (or of *oxygen and aluminum*). The number who used this prepositional phrase was 8, 15, 15, 24, 24. Skilled adults did so still more often: 19 times. In addition, one tenth grader wrote *consisting of aluminum*, another *composed of aluminum*, and a twelfth grader wrote *made up of aluminum*.

For these two kernels the total of reductions to less than a predicate provides strong evidence of a developmental trend: The number is 16, 51, 57, 67, 70. Here we also have the clearest kind of evidence of fourth graders' transformations, the coordinated predicate, being displaced by others as the

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students mature. The coordination of the objects of the full verb is more mature, but the replacement of the verb (*mixture of aluminum and oxygen*) is still more mature.

K25: Workmen separate the aluminum from the oxygen. K26: They (workmen) use electricity.—Of these two sentences, the first was very often retained as a main clause, but the second was very seldom retained as a clause either subordinate or main.

Of those few who did retain the second as a clause, some reduced the first to less than a predicate by using a purposive infinitival: *use electricity to separate*, etc. The number who did so increases up to tenth grade, but twelfth graders strongly preferred a different change, as we shall see in the next paragraph. The number who used the purposive infinitival was 3, 6, 7, 10, 4. Four skilled adults did so. One twelfth grader was even more explicit about his purposive: he wrote *in order to separate*, etc. Two students (grade 8 and grade 10) wrote *by separating*, etc., and one high twelfth grader wrote, *separating*, etc.

K26 was especially likely not to be retained as a main clause. For instance, of the 100 students in the two older grades, only 18 did so. Only two skilled adults did so. No student and no skilled adult retained it as a subordinate clause or even as a coordinated predicate.

The number who reduced it to less than a predicate is strongly indicative of maturity. The number in each grade who did so was 4, 14, 32, 39, 40, an increase at every grade level, with big increases up to grade 10; 22 skilled adults did so.

Several different forms of reduction to less than a predicate were used, and no one of them is clearly more mature than another, though differences are tentatively suggested. The form used most commonly in all grades was *by using electricity* (1, 3, 14, 7, 11; total 36). Another that was more common for younger students was *with electricity* (3, 7, 4, 4, 2; total 20). Another that was less common with the younger students was *by electricity* (0, 2, 5, 6, 10; total 23). Another that was commonest with the two older grades was *by the use of electricity* (0, 0, 5, 11, 10; total 26).

Other reductions to less than a predicate were *using electricity* (0, 0, 3, 5, 1; total 9); *by means of electricity* (0, 1, 0, 2, 4; total 7); *with the use of electricity* (0, 0, 1, 1, 1); *through use of electricity* (0, 0, 0, 1, 1); *with the help of electricity* (0, 0, 0, 1, 0); *electrically* (0, 0, 0, 1, 0).

Skilled adults used a similar variety of prepositional expressions. In addition, six of them used the adverb *electrically* whereas only one student did. Five of them used *electrolysis*, whereas only one student did.

Nearly all of these various reductions made explicit the means-end relationship that was not explicitly stated in any of the input kernels.

K27: They (workmen) finally produce a metal. K28: The metal is light. K29: It (the metal) has a luster. K30: The luster is bright. K31: The luster is silvery.—This series of five sentences is again highly redundant by virtue of its repeated nouns. The direct object of the first sentence becomes the sub-

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ject of the next two descriptive (copula) sentences. The object in the predicate of the third sentence becomes the subject of the fourth and fifth sentences, also with descriptive copulas and predicate adjectives.

The first of the series was especially likely to be retained as a main clause by each grade (35, 35, 27, 32, 30), whereas the other sentences were not. Instead, they were especially likely to be reduced to less than a predicate by older students.

Of those relatively few students who reduced K27 to less than a predicate, 16 of the 21 were in the two older grades. The commonest way to do this was to add *-ing* or *to* to the stem of the verb, producing *to (finally) produce a metal* (1, 3, 0, 1, 3, and 5 skilled adults) or *(finally) producing a metal* (0, 0, 1, 2, 3). Other still less frequent reductions were *leaving (before us) a metal* (0, 0, 0, 1, 1, and 2 skilled adults), *final product* (0, 0, 0, 1, 0), *the end product, a metal* (0, 0, 0, 1, 0), *into a final product* (0, 0, 0, 1, 0), *a metal produced* (0, 0, 0, 0, 1), *produced metal* (0, 0, 0, 1, 0).

Among the other changes, those that did not reduce a main clause to less than a main clause, we see again the tendency to by-pass *the workmen*. One way is to use the passive with agent deleted: *a metal is finally produced*. This way was used more by older students (0, 0, 3, 6, 9). Other ways changed the main clause, and sometimes nominalized the verb *produce* into the noun *product*. For instance, *the final product* (or *the finished product* or *the end product* or *the result* or *it*) *is a metal* appeared with this total frequency: 1, 1, 0, 6, 6. Other students replaced *workmen* with *this process* (or *this* or *it*) *produces* (0, 1, 4, 3, 3).

K28: *The metal is light.*—The number who retained this as a main clause declines sharply with age (37, 22, 12, 11, 3). Only one skilled adult did so. The number who retained it as an adjective clause increases sharply in the sixth grade but then declines to a fairly low level (2, 12, 6, 7, 6). No skilled adult did so.

Older students reduced it to a prenominal adjective modifying the former subject (*light metal*). The frequency is strongly indicative of maturity: 2, 8, 19, 24, 28. Out of 25 skilled adults, 20 did so.

Two more tenth graders and two twelfth graders wrote *lightweight metal*, removing the ambiguity whether the metal was light in color or weight. One tenth grader used the adjective postnominally, *the metal, light*.

This kernel and those that follow were especially likely to be omitted.

K29: *It (the metal) has a luster.*—The number retaining this as a main clause declines sharply with age (31, 18, 13, 3, 5). No skilled adult did so. A fair number of students deleted the subject, coordinating the full predicate (11, 15, 10, 17, 8). No skilled adult did so.

With maturity, the tendency to replace the verb *have* with the preposition *with* (*with a luster*) increased substantially: 1, 4, 6, 11, 10. A still larger proportion of skilled adults (7) did so. Conversion of the noun *luster*

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to the adjective *lustrous* (or one *lustery*) used prenominally occurred occasionally: 0, 1, 4, 2, 3; 4 skilled adults did so.

The few remaining reductions were these: *of a luster* (1 grade 12 and 2 skilled adults), *possessing a luster* (1 grade 10), *lustered metal* (2 grade 12), *lustrously bright* (1 grade 12), *luster finish* (1 grade 12), *luster metal* (1 grade 12). A third of the skilled adults omitted this kernel.

K30: *The luster is bright.*—As students get older, they very clearly learn not to retain this as a main clause (34, 18, 5, 0, 0). The number who retained it as an adjective clause increases into the middle grades and then decreases (1, 8, 5, 1, 0), indicating that, from grades 4 to 6, students learn to reduce this kernel to a subordinate clause and then from there on learn not to—that is, they learn to reduce it further. No skilled adult retained it as a clause.

What students almost invariably learn to reduce it to is a prenominal adjective: 2, 11, 21, 35, 32; 17 skilled adults did so. The word modified is usually *luster*, the original subject of the kernel (84 occasions), or sometimes *metal* (16 occasions), and once *color*.

Four sixth graders coordinated the adjective with another predicate adjective (*the luster is silvery and bright*). So did two skilled adults.

K31: *The luster is silvery.*—Like the other predicate adjective sentences in this study, this kernel was reduced to a prenominal adjective with substantially increasing frequency by older students: 3, 9, 21, 38, 42. Twenty-three skilled adults did so. As in the previous kernel, its twin, the noun usually modified was *luster*, the original subject (87 occasions). And of course the adjectives from both this and the previous kernel were often used together to modify the noun in an earlier kernel, K29, *has a bright, silvery luster.*

Less often the noun modified was *metal* (21 occasions), and occasionally *color* (twice), *bright* (once), *sheen* (once), *substance* (once).

A less mature reduction to less than a predicate was the coordination of this predicate adjective with the retained predicate adjective *bright* in the previous kernel: *the luster is bright and silvery.* This was fairly common in the early and middle grades but rare in the later ones: 8, 20, 10, 0, 2. This less mature reduction makes one kernel out of two. The more mature reduction makes one out of three.

K32: *This metal comes in many forms.*—This is the only one of the 32 kernels which almost no student reduced to less than a predicate. Only two of the 250 did, and they were both eighth graders. They combined this kernel with a reduced form of the much earlier kernel, K3: producing *with many uses and forms.* Skilled adults reduced it five times, often changing the verb to do so.

Whatever power to discriminate this kernel may have is seen in the increasing number of coordinated predicates (0, 2, 8, 7, 11) and, for the middle grades, the increasing number of adjective clauses (0, 1, 10, 12, 9; 6

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skilled adults). The number of students who retained this as a main clause does indeed decline (42, 39, 18, 24, 12; 5 skilled adults).

Though the Not Analyzed category cannot be interpreted unambiguously, the increasing number of writers who omitted this kernel (8, 8, 12, 7, 18; 5 skilled adults) suggests the possibility that older students did so deliberately, feeling it to be extraneous to the rest of the discussion.

When this instrument is used in the future, it would apparently be just as well to omit this last kernel. At least, this kernel discriminates less sharply than any of the others. A student's score on clause length, T-unit length, number of embeddings, etc., would not be appreciably affected whether this kernel was omitted or included.

Lexical Changes

In rewriting the kernels some words were, of course, replaced by synonyms or near synonyms. In K2 *abundant* became *common*. In K3 *has many uses* became *versatile* or *for many purposes*. In K4 *comes from* was replaced by a wide variety of less elementary verbs, sometimes so that passivization could occur. In K6 *looks like* became *resembles*. In K7 and K8 *X contains Y and Z* became *X occurs in combination with Y and Z*. In K8 *other substances* became *impurities* or *extraneous materials*. In K13 *form a mass* became *coagulate*, or *are precipitated as a mass*. And *other* substances became *foreign*, *unwanted* substances. In K14 *remove* became *discard, the mass* became *solid form* or *heavier elements*. In K16 the *remaining liquid* became the *liquid residue*. In K18 the *chemical* became *oxide* or *compound,* and in K22 the *mixture* became a *compound*. In K27 *produce* a metal became *generate* or *obtain* or *leaves*. In K32 *comes* in many forms became *is manufactured, is marketed, is fabricated, is cast, rolled,* or *stamped*.

The lexical changes just listed were, as a matter of fact, those made by the skilled adults. On the whole the new words were more exact, more learned.

Substitutions made by the students were not always more learned words. For instance, in K9 *extract* was changed to *remove* by a student or two in each grade. It was changed to *separate* by two twelfth graders. It was changed to *take out* by an eighth grader and a tenth grader. A sixth grader changed it to *get out*. Some of these synonyms seem to be translations down, rather than up, to the writer's own level.

Similarly, in K14, *remove* was changed to *take away* by a sixth grader, *take off* by a fourth grader, and *take out* by a twelfth grader.

The only changes that were syntactically interesting were those that solved the problem already mentioned concerning those sentences in which workmen were said to do something. To get rid of the subject word *workmen* the passive with agent deletion was often used. However, another solution was to use a verb of a different sort. For instance, in K17 the workmen *put* the liquid *through* other processes. Students replaced *put through* with

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a verb which takes *the liquid,* former object, as subject: *the liquid undergoes, goes through, is processed.* Just as the passive was used more often by older students to solve this problem, so these changes were made more often by older students. The change in lexicon facilitated a change in syntax.

In K18 the liquid *yields* a chemical. Older students sometimes chose *chemical,* former object, as their subject. Two twelfth graders used the passive, *is yielded.* But a dozen others, perhaps because they felt uncomfortable with *yielded,* substituted *is made, is formed, is left, is produced, is obtained, remains.*

It certainly is no surprise to anyone that the two older grades made somewhat more lexical changes than the two younger grades: 6, 21, 10, 22, 30. The lexical changes made on this instrument are much less revealing than the syntactic changes.

Summary

As the earlier chapters reported on the number of transformations that reduced the main clause inputs to subordinate clauses and to coordinate predicates, so this chapter focuses on the particular transformations that reduced the inputs to less than a predicate. Every syntactic change made by every writer was first tabulated, and all but the most idiosyncratic of those changes have been reported here. The summary of them appears in table 10, and a discussion of them sentence by sentence follows the table.

This report demonstrates that not only do successively older writers reduce more inputs to less than a predicate, but they use a wider variety of transformations in doing so. One way to indicate this growth in variety in quantitative terms is to count the number of different changes made in inputs as enumerated in table 10. For each successive grade, the number is 27, 38, 48, 59, 65, a steady increase. This greater variety indicates that older writers have a wider repertoire of syntactic resources to draw upon when confronted with problems of sentence construction.

One can scarcely escape the conclusion that as writers mature they take advantage of more and more opportunities for consolidating sentences. No doubt, diminishing returns would set in at some point along the line if carried to too great an extreme, but the evidence presented for skilled adults indicates that the point of diminishing returns is so far in advance of the point reached by schoolchildren that curriculum makers need not worry about this matter.

A second contribution made by this chapter is the demonstration that, among these transformations, some seem to indicate greater maturity than others. For instance in K19 and K20 the number of writers who coordinated one of the predicate adjectives with the other was, for successive grades, 9, 18, 13, 5, 3; skilled adults 0, indicating growth from grades 4 to 6 and 8, and a decline thereafter. This transformation was not used by more mature writers; instead, they reduced the two predicate adjective sentences

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to prenominal adjectives with this frequency for successive grades: 1, 26, 53, 73, 83; skilled adults 45 (90). In effect, then, the one transformation is used early but then is displaced by another still more mature.

A third contribution made by this chapter is that it seems to settle a question that was raised by Hunt's 1965 study but could not be answered by any study of free writing. It is well known that older writers have more to say on most subjects than younger writers do. Could it be that the differences in sentence structures between younger and older writers is due in large part to what is said? Could it be that what older writers add is, in some undefined sense, elaborative, peripheral, and subordinate, so that it is this extra subject matter that requires longer clauses and longer T-units?

In this experiment, all writers were constrained to say the same thing. When a writer added something not contained in the original, the whole sentence was deleted. Yet, even so, the older writers showed the same syntactic superiority they showed in free writing, suggesting that their sentences are affected by their syntactic ability, not just by what they have to say.

A fourth observation is that older writers tended to add meanings that were not explicitly stated in the inputs. For instance, the half-dozen inputs describing the manufacturing sequence were arranged in the correct time order, but only one of them indicated a time relation. However, as the children got older they were more likely to make that information explicit. They tended to use more often such time-relation words as *then*, and also *until* and *when*, introducing subordinate clauses. Furthermore, though the various steps of the process were related as means and ends, the input sentences did not say so. Nonetheless, older writers tended to make that relation more often explicit by devices such as the purposive infinitival, *(in order) to do this they do this,* or an expression of means, *they do this by doing this.*

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VI. IMPLICATIONS AND APPLICATIONS

Without the concepts of transformational syntax, researchers into syntactic development were confronted by such a bewildering diversity of sentence structures that there seemed to be no more than about two concepts by which simple sentences could be related to complicated ones. The very simplest sentence patterns can be found again and again, but more elaborate ones almost never are: each seems to be unique. One might find in a very easy reader a first sentence whose sequence is article, noun, copula verb, adjective. And he might not need to look very far before he would find that pattern duplicated. At least such is the case with the input Aluminum passage. But if, instead, one opened a book of ordinary prose whose first sentence was 10, 15, or 20 words long, the likelihood of finding that same sequence of syntactic items duplicated would be almost nil.

For decades there seemed to be no set of concepts to relate simple sentences to complicated ones except in rather external ways. The number of words in a sentence would relate them, and it is indeed true that more complicated and mature sentences tend to be longer. And although syntactic items such as parts of speech turn out not to be worth counting, nonetheless subordinate clauses do tend to increase with the maturity of the writer. McCarthy observed in her classic review in 1954 that these two syntactic measures were the only ones that were shown to be positively related to growth from the early grades to graduation, yet to the writing teacher these measures must have seemed external and even irrelevant.

Even without the concepts of deep structure, transformations, and surface structure, an investigator who noted that the coordination of main clauses actually declines in writing during the early to middle grades might have realized that overcoordination tends to lengthen sentences spuriously. Noting that, he might have concluded that the syntactic unit here called the T-unit would be one whose length would be a better measure of maturity than sentence length. Indeed, in 1961 Loban seems to have used a unit much like the T-unit. He defined his "communication unit" as "that group of words which cannot be further divided without the loss of their essential meaning," and added that "these units prove to be not solely semantic; in most cases they are also syntactic, being composed of independent predica-

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tions." He did break a compound sentence into separate units. In these respects his communication unit is perhaps exactly like a T-unit. But his original communication unit differed from the T-unit in that it need not contain a full clause. "On the other hand, 'Yes' can be a unit of communication when it is the answer to a question such as, 'Have you ever been sick?' " By themselves, answers to questions would not satisfy the requirement that a T-unit contains at least one subject and one predicate. Lumping answers together with T-units would affect the results either much or little, depending on whether the answers were short like "yes" and frequent in the discourse, or whether they were about as long as T-units and infrequent in the discourse. Anyway, Loban used a unit much like a T-unit as early as 1961 and found an increase in length with maturity.

Without considering transformational syntax, a researcher—if he was looking across the whole span of school years—might also have noted that mean clause length increases. When one looks at La Brant's (1933) actual data on the clause length of elementary and high school children, it seems that she might easily have considered the increase important, especially since she also observed that eminent psychologists used "nearly twice as many words to a clause" (p. 474) as her schoolchildren. Nonetheless, most researchers, studying a narrow span of grades, did not consider clause length an important measure of maturity.

Still looking only at the surface structures of sentences, researchers might have observed the increase in T-unit length and in clause length, just as they did note the increases in sentence length and number of subordinate clauses. And they might have defined these syntactic entities in such a way that the five measures—w/c, c/T, w/T, T/s, w/s—would be arithmetically interrelated, and it would then be possible to see how an increase or decrease in one affected the others. Without such definitions, researchers instead concluded, "Apparently length of clause is somewhat controlled or restricted by the structure of the language, and whatever increase in sentence length occurs at higher age levels is brought about largely through the addition of more subordinate clauses" (McCarthy 1954).

But knowing about the measure of clause length and T-unit length, however useful it may be to the researcher, is still no help to the teacher, and gives her no sense of insight into growth in syntax. These measures must still seem external and even irrelevant to what her children do. She would never be so inane as to tell them, "I want you to add two or three words to each of your sentences. Then you will be writing like sixth graders instead of fourth graders."

So long as it appeared as if the longer clauses or T-units or sentences of older children were a matter only of adding words or thoughts, then these measures would have little use in the schoolroom. But against the backdrop of transformational theory, the present study demonstrates that even when no words and no information are added by the older writer, he achieves more words per clause, more words per T-unit, and more per sentence.

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La Brant saw that something of this sort happened, for in commenting on the longer clauses written by eminent psychologists, she said, "This increase in length is apparently occasioned by the reduction of clauses to participial and infinitive phrases and by the elision of words, phrases and clauses" (p. 474). Perhaps that same "reduction" and same "elision" has been noted in this study as an increase in *Ving*, *to V*, and in other reductions to nonclausal structures. But without an explicit theory of sentence-embedding transformations, it seems most unlikely that any researcher could have quantified the observations La Brant reported or could have told which words and phrases should be counted as reductions of clauses and which should not.

In Chapter IV certain tenets of transformational syntax were reported in grossly simplified form. The tenets relevant here are that: (*a*) the deep structure of complicated sentences is represented as successive embeddings of elementary sentences, conveniently shown in a branching diagram; (*b*) this branching diagram represents the meaning of the sentence though not the form in which it is spoken or written; (*c*) the spoken or written form is the "surface" structure, and it is produced by applying to each elementary sentence, beginning with the bottommost, one of the sentence-combining or generalized transformations that is appropriate in view of both the structure of the sentence to be embedded and the structure in which it is to be embedded. The structure so created is then operated on by another transformation which embeds it inside the one immediately above, and so on until the uppermost is reached and a linear order is produced.

It is this view which provides the concepts by which simple sentences can be related to complicated ones. First of all, it supposes that the number of different syntactic shapes of the elementary sentences themselves is relatively few. Second, it supposes that the number of different combining transformations is also relatively few. But the number of possible combinations and permutations of these relatively few elementary sentences and these relatively few transformations is vast. The possible variations are so immense that in a book of ordinary prose the syntactic structure of the first sentence is likely not to be duplicated exactly by any other in the book.

To illustrate this point, consider the number of ways of combining the first four input sentences of the Aluminum passage. Any or all can serve as main clauses. Since all contain the same subject, then any 2, any 3, or all 4 could be combined by coordinating the predicates. Alternatively, any 2, 3, or all 4 could be combined using the relative adjective clause transformation. The first also contains a predicate nominal so it could be embedded in any of the others as an appositive. The second contains a predicate adjective which could become a prenominal adjective in any of the others. The third, "It has many uses," was transformed in three different ways. The fourth, like the first, could become an appositive. These possibilities alone are enough to produce several hundred different surface structures. So the likelihood of being able to compare one surface structure with another is indeed remote,

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except by external measures such as word lengths. The possibility of comparing the deep structures of a simple sentence and a complicated one is much less remote.

The basic thesis of this study is that as schoolchildren mature mentally they tend to embed more of their elementary sentences, their kernel strings. This is a psychological, a behavioral phenomenon. The fact that they do so and also that they transform these in different ways at different age levels is used to explain the five external measures of syntactic maturity. These five measures show the effect on surface structure of the basic behavioral phenomenon represented in the deep structure and the transformations.

It is possible that this behavioral tendency is the result merely of stylistic imitation. Possibly by reading more mature sentences and listening to them children learn to copy adult patterns more often. Perhaps this adult style is merely a convention serving no useful purpose. If studies of the sort reported here were made on native writers and speakers of other languages, particularly non-European languages, then we would have more evidence of whether this developmental tendency is universal. There are, of course, advantages other than imitation of an adult convention that are gained by multiple embedding. Often it deletes words, thus increasing succinctness and reducing redundancy.

A more attractive explanation is that as the mind matures it organizes information more intricately and so can produce and receive more intricately organized sentences. Support for some such notion is provided by the theory of "chunking" which Miller (1956) developed. He suggested that the number of chunks of information the human mind can perceive, process, and remember is roughly seven, plus or minus two. As evidence, he drew examples from a wide variety of experiments. But he also showed that, although we ordinarily can remember only about seven digits, we can, if we learn to recode these bits into larger chunks, reproduce from immediate memory some 40 digits. Generalizing from this and other evidence, he went on to discuss the processing of recoding, distinguishing between bits and chunks of information. "Since the memory span is a fixed number of chunks, we can increase the number of bits of information that it contains simply by building larger and larger chunks, each chunk containing more information than before . . . In the jargon of communication theory, this process would be called recoding. The input is given in a code that contains many chunks with few bits per chunk. The operator recodes the input into another code that contains fewer chunks with more bits per chunk. There are many ways to do this recoding but probably the simplest is to group the input events, apply a new name to the group, and then remember the new name rather than the original input events" (p. 93).

Though Miller cites no experiments like the present study, the general description of recoding which he gives seems to apply in a remarkable degree to the process of rewriting as it is practiced by more and more mature persons. Each input kernel is a chunk containing a certain small number of

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bits. Each output *T*-unit is also a chunk, but, as rewritten by the more mature writer, it now subsumes within it other recoded chunks so as now to contain a large number of bits. The recursive *S* is just such a device as to allow a small number of nodes to dominate many bits of information.

The Aluminum Passage as a Measuring Instrument

The instrument used here as a research instrument has obvious uses for the measurement of syntactic maturity in new populations. An experimental curriculum designed to accelerate syntactic maturity might well use this instrument as one of the devices for measuring the success of the program.

The great advantage of this instrument over measuring free writing is the speed with which this instrument can be administered and scored. At any grade level it is virtually self-administering and can be completed in a class period of about 40 minutes. To score it requires only a knowledge of what is and what is not a clause. The scorer should be able to mark the beginning of each clause in a paper in a couple of minutes. Anyone can then count the number of clauses, the number of words, and divide the latter by the former to get mean clause length, which would serve as the score of the writer's maturity. The scores provided in this study would be used as something approaching norms.

The disadvantage of this instrument is that no one knows whether students would be ranked by this instrument in the same order in which they would be ranked for syntactic maturity by objective measures of several thousand words of their own free writing, preferably on a variety of topics.

Although the reliability of the instrument was not checked by administering it to the same students a second time, something can be inferred about its reliability by comparing the scores of individuals on this instrument and on another instrument of a similar sort but telling a story, which was in fact administered to them on either the preceding or following day. The clause length scores of the 50 fourth graders on the two instruments correlate .55; a correlation of .23 would have been significant at the .05 level. The clause length scores of the middle group of students in all five grades on the two instruments correlated .73.

It is pertinent to cite, as data recommending this instrument, that it gives a significant difference at every 2-year interval from grade 4 to grade 12 and for skilled adults. Whatever is proposed as a better measuring device should possess a superior power of discrimination over a comparable range of grades and of abilities.

On the Aluminum instrument, scoring the number of reductions to less than a predicate might give a more valid score than clause length, At least, it is true that between grades 4 and 6, 6 and 8, 8 and 10, 12 and skilled adults, the differences in scores on less than predicates were significant at the .005 level. Only between grades 10 and 12 did the significance drop to the .05 level. But to score a paper for clause length is much quicker and easier

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than to score it for this measure, and the correlation between the two scores is high enough to justify use of the less expensive score.

Implications for the Curriculum

At least two curricula designed to increase sentence-embedding have been tried out for a year and have been tested to see whether they produce more than the usual amount of growth in the students' writing.

One study (Mellon 1967) was made in the seventh grade; one (Miller & Ney 1968) was made in fourth. Both report that the experimental group showed significantly more growth than a comparable control group, and neither experimenter observed any deleterious effects.

a) In view of these successful first attempts it seems advisable that a variety of curricula be designed to facilitate syntactic maturity.

b) It seems advisable that a sequential curriculum on syntactic maturity covering many grades, perhaps all, should be undertaken.

c) It seems advisable that teachers of writing at all levels should be trained in at least the rudiments of transformational theory. Though, like any other scientific theory, this one is neither complete, definitive, nor static, it does offer useful insights to the teacher.

Implication for Further Research

a) The findings of this study or the studies by Hunt and O'Donnell on free writing and speech would profitably be replicated, especially on a larger and carefully chosen population from another part of the country.

b) The rewriting of elementary sentences might be used to see whether schoolchildren at different ages do indeed use the full repertoire of adult sentence-combining transformations. No opportunity was given in the Aluminum passage to use certain transformations—for instance, extraposition of noun clauses and infinitivals.

c) Whether the Aluminum passage measures what is demonstrated by a student in his own free writing could be ascertained. The actual clause length or *T*-unit length scores would of course not be used for comparison, but instead several students would be ranked by their scores on the Aluminum passage and then by their scores for syntactic maturity on free writing. To assure an adequate sample of free writing, perhaps several thousand words would be needed from each writer, and perhaps the writing would need to cover a variety of types of discourse. The more similar the writers, the more likely it would be for the two rankings to differ.

d) Psycholinguistic research could address itself to the question of whether the multiple embedding that is characteristic of older writers makes it possible for information to be processed more easily by adults and, alternatively, by children.

e) This study has stressed the importance of deep structure in the meas-

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urement of syntactic maturity, but the writing teacher knows that the reada-bility of a sentence depends on its surface structure. The techniques of psycholinguistic research could be used to rank, for understandability at a first reading, the various surface structures derivable from the same deep structure.

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GRADE 4

1. *Aluminum is a metal*   *and is abundant.*
   [K1: Aluminum is a metal]   [K2: It is abundant]

2. *It has many uses*   *and it comes from bauxite.*
   [K3: It has many uses]   [K4: It comes from bauxite]

3. *Bauxite is an ore*   *and bauxite looks like clay.*
   [K5: Bauxite is an ore]   [K6: Bauxite looks like clay]

4. *Bauxite contains aluminum*   *and it contains several other substances.*
   [K7: Bauxite contains aluminum]   [K8: It contains several other substances]

5. *Workmen extract these other substances from the bauxite.*
   [K9: Workmen extract these other substances from the bauxite]

6. *They grind the bauxite*   *and put it in tanks*
   [K10: They grind the bauxite]   [K11: They put it in tanks]

7. *Pressure is in the tanks*   *and other substances form a mass.*
   [K12: Pressure is in the tanks] [K13: The other substances form a mass]

8. *They use filters*   *to remove the mass*   *and a liquid remains.*
   [K15: They use filters] [K14: They remove   [K16: A liquid remains]
                             the mass]

9. *They put it through several other processes*
   [K17: They put it through several other processes]

   and it finally yields a chemical.
   [K18: It finally yields a chemical]

10. *The chemical is powdery*   *and it is white.*
    [K19: The chemical is powdery]   [K20: It is white]

11. *The chemical is aluminum*   *and it is a mixture.*
    [K21: The chemical is alumina]   [K22: It is a mixture]

12. *It contains aluminum*   *and it contains oxygen.*
    [K23: It contains aluminum]   [K24: It contains oxygen]

13. *Workmen use electricity*   *to separate the aluminum from the oxygen.*
    [K26: They use electricity]   [K25: Workmen separate the aluminum
                                      from the oxygen]

14. *They finally produce a metal*   *and the metal is light.*
    [K27: They finally produce a metal] [K28: The metal is light]

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15. *It has a luster*   *and the luster is bright.*
    [K29: It has a luster]   [K30: The luster is bright]

16. *The luster is silvery*   *and this metal comes in many forms.*
    [K31: The luster is silvery]   [K32: This metal comes in many forms]

GRADE 8

1. *Aluminum is an abundant metal, has many uses,*   *and comes from*
   [K1: Aluminum is a metal] [K3: It has many uses]   *bauxite*
   [K2: It is abundant]   [K4: It comes from
                                                          bauxite]

   which is an ore   *that looks like clay.*
   [K5: Bauxite is an ore] [K6: Bauxite looks like clay]

2. *Bauxite contains several other substances.*
   [K8: It contains several other substances]

3. *Workmen extract these from bauxite*
   [K9: Workmen extract these other substances from bauxite]

   by grinding it,   *then putting it in pressure tanks*
   [K10: They grind the bauxite] [K11: They put it in tanks]
                                  [K12: Pressure is in the tanks]

   where the other substances form a mass.
   [K13: The other substances form a mass]

4. *The mass is removed*   *by filters*   *and a liquid remains.*
   [K14: They remove   [K15: They use filters]   [K16: A liquid remains]
     the mass]

5. *Then the liquid is put through several other processes*
   [K17: They put it through several other processes]

   and finally it yields a chemical   *which is a powdery white color.*
   [K18: It finally yields a chemical] [K19: The chemical is powdery]
                                        [K20: The chemical is white]

6. *This chemical is an aluminum mixture   which contains oxygen.*
   [K22: It is a mixture]   [K24: It contains oxygen]
   [K23: It contains aluminum]

7. *Workmen separate the aluminum from oxygen by use of electricity.*
   [K25: Workmen separate the aluminum from oxygen]
                                        [K26: They use electricity]

8. *Finally a metal is produced.*
   [K27: They finally produce a metal]

9. *This metal is light*   *and has a luster*   *which is bright and*
   [K28: The metal is   [K29: It has a luster]   *silvery.*
     light]   [K30: The luster is
                                                     bright]
                                                  [K31: The luster is
                                                     silvery]

10. *This metal comes in many forms.*
    [K32: This metal comes in many forms]

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MONOGRAPHS

GRADE 12

1. *Aluminum is an abundant metal with many uses.*
   [K1: Aluminum is a metal]   [K3: It has many uses]
   [K2: It is abundant]

2. *It comes from an ore   called bauxite   that looks like clay.*
   [K4: It comes from   [K5: Bauxite is an ore]   [K6: Bauxite looks like
   bauxite]   clay]

3. *It contains aluminum   and several other substances*
   [K7: Bauxite contains aluminum]   [K8: It contains several other
                                            substances]

   which are extracted from the bauxite.
   [K9: Workmen extract these other substances from the bauxite]

4. *They grind the bauxite   and put it in pressure tanks.*
   [K10: They grind the bauxite]   [K11: They put it in tanks]
                                     [K12: Pressure is in the tanks]

5. *The other substances form a mass   which is removed by filters.*
   [K13: The other substances form a   [K14: They remove the mass]
   mass]   [K15: They use filters]

6. *The remaining liquid   is put through other processes*
   [K16: A liquid remains]   [K17: They put it through several other processes]

   where it finally produces a white, powdery chemical   called alumina.
   [K18: It finally yields a chemical]   [K21: The chemical is
   [K20: It is white]   alumina]
   [K19: It is powdery]

7. *It is a mixture   containing aluminum   and oxygen*
   [K22: It is a   [K23: It contains   [K24: It contains oxygen]
   mixture]   aluminum]

   which are soon separated from each other   by electricity.
   [K25: Workmen separate the aluminum   [K26: They use electricity]
   from the oxygen]

8. *Finally, a light lustrous metal is formed.*
   [K27: They finally produce a metal]
   [K28: The metal is light]
   [K29: It has a luster]

9. *It has a silver sheen to it   and comes in many forms.*
   [K31: The luster is silvery]   [K32: This metal comes in many forms]

SKILLED ADULT

1. *Aluminum, an abundant metal   of many uses,   is obtained from*
   [K1: Aluminum is a metal]   [K3: It has many   bauxite
   [K2: It is abundant]   uses]   [K4: It comes from
                                                      bauxite]

   a clay-like ore.
   [K5: Bauxite is an ore]
   [K6: Bauxite looks like clay]

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2. *To extract the other substances*   *found in bauxite*
   [K9: Workmen extract these other substances from the bauxite]
   [K7: Bauxite contains aluminum (omitted, entailed by K4)]
   [K8: It contains several other substances
   (omitted, entailed by K9)]

   the ore is ground   *and put in pressure tanks.*
   [K10: They grind the bauxite]   [K11: They put it in tanks]
                                   [K12: Pressure is in the tanks]

3. *Under pressure these other elements form a mass*   *which can be removed.*
   [See K12]   [K13: The other substances form a mass] [K14: They remove
                                                           the mass]

4. *The remaining liquid   is filtered*   *and put through other processes*
   [K16: A liquid remains]   [K15: They use filters] [K17: They put it through
                                                     several other processes]

   which finally yield a powdery   *white   chemical,   alumina,*
   [K18: It finally yields a chemical]   [K21: The chemical is alumina]
   [K19: The chemical is powdery]
   [K20: It is white]

   a mixture   *of aluminum*   *and oxygen.*
   [K22: It is a]   [K23: It contains   [K24: It contains oxygen]
      mixture]   aluminum]

5. *The oxygen is removed*   *by electrolysis,*   *leaving*
   [K25: Workmen separate the aluminum from the oxygen]
                           [K26: They use electricity]
                                                [K27: They finally
                                                produce a metal]
   a bright   *lustrous*
   [K30: The luster is bright]   [K29: It has a luster]
                                    [K28: The metal is light (entirely omitted)]

   silvery   *metal,*   *which is marketed in many forms.*
   [K31: The luster   [See K27]   [K32: This metal comes in many
      is silvery]   forms]