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SCIENTIFIC ENGLISH AND THAI STUDENTS:
A STUDY OF THE COMPREHENSIBILITY OF COMPLEX STRUCTURES

BY

(pl)
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ABSTRACT

This study attempted to examine (i) the relationship between Thai science students' comprehension of English complex structures and their reading comprehension of scientific English passages, (ii) the patterns among comprehensibility levels of complex structures for good and poor readers and (iii) the differences in the comprehensibility of complex structures within given types for good and poor readers, taken separately.

The sample comprised 190 subjects who were drawn from five different Faculties at Khon Kaen University -- Medicine, Nursing, Science, Agriculture and Education. Four tests were constructed -- two measuring comprehension of scientific English, two measuring comprehension of three types of complex structures, viz., complements, comparatives and relatives.

On the basis of cloze reading scores, 40 good readers and 43 poor readers were identified. Their structure comprehension scores were analyzed and compared.

The results revealed that comprehension of English complex structures and reading comprehension of scientific English passages were positively related. When comprehensibility levels of complex structures were examined for patterns and when patterns characteristic of good and poor readers were compared, the results revealed a group of structures easy for both groups and another group of structures which tended to be relatively difficult for both groups. Easy structures seemed to share several general features notably the presence of particular types of surface cues in the surface structures, the presence of all surface elements and overt rather than covert ordering of surface elements within clauses. Difficult structures, on the other hand, displayed different types of surface cues or had surface cues absent from the surface structures. Moreover in such difficult structures, not all surface elements were present.

It was also found that there were differences in the comprehensibility levels of complex structures within the different types. Again the presence or absence of surface cues seemed to affect sentence comprehensibility. The easier structures within the different types tended to contain the surface elements required to understand the sentence.

The position of the relative clause seemed also to have an effect on the comprehensibility level of relative sentences. Right-branching relative clauses seemed to be more comprehensible than centre-embedded relative clauses.

Finally the data revealed that good readers comprehended complex structures significantly better than did poor readers in most of the structures investigated. Their comprehension of two complex structures, however, was found not significantly different. They were (i) Non-finite (to-infinitive) object complement and (ii) Comparison of inequality where than is absent. Some explanation of the results was attempted and some educational implications were drawn.

This thesis is dedicated

to

my parents

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TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	v
LIST OF TABLES	xv
LIST OF FIGURES	xix
INTRODUCTION AND BACKGROUND	1
Importance of English Language Learning for Thai Science Students	1
Situation of English Language Teaching for Thai Science Students at the University Level in Thailand	1
Significance of the Present Study	4
Order of Presentation	6
CHAPTER 1: REVIEW OF THE LITERATURE	8
Introduction	8
Reading Process	8
First Language Reading	9
Foreign or Second Language Reading	13
Conclusion	16
Linguistic Research on English for Science and Technology (EST)	17
English Language Teaching and English for Special Purposes (ESP)	17
Linguistic Research on English for Science and Technology (EST)	19
Lexical Analysis	19
Syntactic Analysis	20
Discourse Analysis	24
Conclusion	26
Research on Language Structure and Reading Comprehension	27
Knowledge of English Grammatical Structures and Reading Comprehension	27
Readability and Sentence Structure	31
English Complex Structures	37
English Relative Clauses	37
English Complement Structures	47
Conclusion	51

	Page
"Cloze" Technique	52
Definition	52
Validity: Cloze as a Measure of Reading Comprehension for Native Speakers	53
Validity: Cloze as a Measure of Reading Comprehension for Non-native Speakers of English	57
Cloze Test Reliability	58
Methodological Considerations	60
Scoring Procedure	62
Conclusion	64
 CHAPTER 2: RESEARCH DESIGN	 66
Introduction	66
Research Questions	66
Hypotheses	73
Sample	77
Composition of the Sample	78
Instruments	80
Cloze Reading Comprehension Test	81
Multiple-choice Reading Comprehension Test	81
Test of Comprehension of English Grammatical Structures	81
English-Thai Translation Test of Comprehension of English Grammatical Structures	81
KKU English Language Proficiency Test	82
Collection of the Data	82
Treatment of the Data	82
Test Scoring	82
Computation	83
Summary	84
 CHAPTER 3: TEST CONSTRUCTION	 85
Construction of the Cloze Reading Comprehension Test	85
Selection of the Sample Passages	85
Construction of Cloze Items	86
Pilot Testing II	<u>87</u>
Test Sample	87
Test Administration	88
Scoring Procedure	88
Results	89
Construction of the Multiple-choice Reading Comprehension Test	90
Selection of the Test Passages	90
Construction of the Multiple-choice Items	90

	Page
Pilot Testing I	100
Test Administration	100
Scoring Procedure	100
Results	101
Pilot Testing II	102
Test Sample	102
Test Administration	102
Scoring Procedure	102
Results	103
Construction of the Test of English	
Grammatical Structures	104
Selection of the 15 English	
Grammatical Structures	104
Relative Construction in Scientific	
English	105
Restrictive Clauses of Non-finite	
Construction	106
Restrictive Clauses of Finite	
Construction	107
Complement Structures in Scientific	
English	109
Finite Complements	110
Non-finite Complements	111
Preposition-governed Complements	114
Comparative Constructions in	
Scientific English	116
Comparisons of Similarities or	
Differences	117
Comparisons of Inequality	120
Comparisons of Equality	122
Construction of the Test Items	124
Selection of the Target Sentences	124
Vocabulary Control	125
Construction of the Multiple-choice	
Items	126
Pilot Testing	129
Test Sample	129
Test Administration	130
Scoring Procedure	130
Results	130
Sample Items Measuring English Complex	
Structures	132
Construction of the English-Thai	
Translation Test of English	
Grammatical Structures	138
Selection of the 15 English	
Grammatical Structures	138
Selection of the 45 Target Sentences	138
Pilot Testing	138
Test Sample	138
Test Administration	138
Scoring Procedure	139
Conclusions	139

	Page
CHAPTER 4: TEST ADMINISTRATION AND TEST RESULTS	141
Procedures	141
Time Arrangement	141
Student Co-operation	141
Room Arrangement	142
Cloze Test Administration	143
Test Booklet	143
Test Administration	143
Scoring Procedure	145
Exact Word Scoring Procedure	145
Acceptable Word Scoring Procedure	145
Results	147
Reliability	148
Validity	148
Multiple-choice Reading Comprehension Test:	
Administration	149
Test Booklet	149
Test Administration	149
Scoring Procedure	150
Results	151
Reliability	151
Validity	151
English Grammatical Structures Test:	
Administration	154
Test Administration	154
Scoring Procedure	155
Results	155
Reliability	156
Validity	156
English-Thai Translation Test of English	
Grammatical Structures: Administration	157
Scoring Procedure	158
Results	158
Reliability	159
Validity	159
CHAPTER 5: RESULTS	160
Introduction	160
Findings: Relationship Between Comprehen-	
sion of English Complex Structures and	
Reading Comprehension of Scientific	
English Discourse	160
Product - moment Correlations	161
Partial Correlations	161
Sex	163
Conclusions	165
Difference Between Reading Performance	
of Two Reading Ability Groups	166

	Page
Findings: Relationship Between Good and Poor Readers' Comprehension of the 15 English Complex Structures	170
Spearman Rank-order Correlation	172
Conclusions	178
Findings: Differences in the Comprehensibility Levels of English Complex Structures for Good and Poor Readers	180
Comprehensibility Levels of Three Main Types of English Complex Structures -- Complements, Comparatives and Relatives	180
Single-factor Analyses of Variance (Repeated Measures)	181
Comprehensibility Levels of the Five Different Manifestations of English Complements for Good and Poor Readers	185
Single-factor Analyses of Variance (Repeated Measures)	186
Comprehensibility Levels of the Five English Comparative Structures for Good and Poor Readers	188
Single-factor Analyses of Variance (Repeated Measures)	190
Comprehensibility Levels of the Five English Relative Structures for Good and Poor Readers	192
Single-factor Analyses of Variance (Repeated Measures)	194
Conclusions	196
 CHAPTER 6: DISCUSSION OF RESULTS	 198
Introduction	198
Relationship Between Comprehension of English Complex Structures and Reading Comprehension of Scientific English Discourse	198
Relationship Between Good and Poor Reader Comprehension Patterns of English Complex Structures	200
Comprehensibility Levels of Complex Structures for Good and Poor Readers	204
Comprehensibility Levels of the Three main Types of Complex Structures	204
Good Readers	204
Poor Readers	205
Good Readers vs Poor Readers	205

	Page
Comprehensibility Levels of the Five Complement Structures	206
Good Readers	206
Poor Readers	209
Good Readers vs Poor Readers	210
Comprehensibility Levels of the Five Comparative Structures	212
Good Readers	213
Poor Readers	216
Good Readers vs Poor Readers	217
Comprehensibility Levels of the Five Relative Structures	220
Good Readers	221
Poor Readers	227
Good Readers vs Poor Readers	227
Conclusions	230
 CHAPTER 7: CONCLUSION AND EDUCATIONAL IMPLICATIONS	 232
General Conclusion	232
Educational Implications	234
Cloze Technique	234
Cloze Scoring Methods	235
Scientific English and Its Relationship to Language Structure	235
Patterns of Complex Structures Comprehension and Reading Ability	236
Comprehensibility Levels of the Complements, the Comparatives and the Relatives for Good and Poor Readers Taken Separately	237
The Test of English Grammatical Structures	237
Implications for Future Research	238
 APPENDICES	
A. Cloze Reading Comprehension Test	240
B. Multiple-choice Reading Comprehension Test	248
C. Test of English Grammatical Structures	265
D. Test of English Grammatical Structures - Administration	281
E. Answer Key for the Test of English Grammatical Structures	285
F. Talk Given to KKU Science Students	286
G. Letter to KKU Science Students	290
H. Cloze Reading Comprehension Test - Administration	293 293
I. Answer Key for the Cloze Reading Comprehension Test (Exact Word Responses)	300

	Page
J. Answer Key for the Cloze Reading Comprehension Test (Acceptable Word Responses)	301
K. Multiple-choice Reading Comprehension Test - Administration	303
L. Answer for the Multiple-choice Reading Comprehension Test	306
M. Multiple-choice Reading Comprehension Test - Test Item Statistics	307
N. Correct Response Lengths in the Multiple-choice Reading Comprehension Test	308
O. Vocabulary List	309
P. Test of English Grammatical Structures - Test Item Statistics	320
Q. English-Thai Translation Test of English Grammatical Structures - Administration	321
R. English-Thai Translation Test of English Grammatical Structures	324
S. Key for the English-Thai Translation Test of English Grammatical Structures	335
T. Distribution of Cloze Reading Scores	340
U. Scheffé Multiple Comparisons	342
REFERENCES	345

LIST OF TABLES

Table	Page
1. Validity of Cloze Tests as Measures of General Reading Comprehension	54
2. Sample by Faculties	78
3. Sample Composition: Age and Sex	79
4. Composition of Sample: Age and Reading Ability Sex and Reading Ability	79
5. Cloze Test (Exact Word Scoring): Basic Statistics	89
6. Cloze Test (Acceptable Word Scoring): Basic Statistics	89
7. Comprehension Specifications	91
8. Multiple-choice Reading Comprehension Test: Basic Statistics (Pilot Testing I)	101
9. Multiple-choice Reading Comprehension Test: Basic Statistics (Pilot Testing II)	103
10. Relativilization (791)	106
11. Relative Constructions: Non-finite (Restrictive)	106
12. Relative Constructions: Finite (Restrictive)	107
13. Complementation (725)	110
14. Finite Complements	111
15. Non-finite Complements	112
16. Object Complements with To-infinitive Phrases	113
17. Preposition-governed Complements	114
18. Comparative Structures (518)	117
19. Comparisons of Similarities and Differences	118
20. Functions of the Comparative Elements <u>same</u> and <u>other</u>	119
21. Comparisons of Inequality: <u>more</u> , <u>less</u> , <u>-er</u>	122
22. Comparisons of Equality: so/as	123
23. English Grammatical Structures Test: Basic Statistics	131
24. Cloze Test (Exact Word Scoring): Basic Statistics	147
25. Cloze Test (Acceptable Word Scoring): Basic Statistics	147
26. Multiple-choice Reading Comprehension Test: Basic Statistics	151
27. Test of English Grammatical Structures: Basic Statistics	156

Table	Page
28. English-Thai Translation Test of English Grammatical Structures: Basic Statistics	159
29. Correlation between Structure Comprehension and Reading Comprehension (N = 190)	161
30. Correlational Matrix: Structure Comprehension Scores, Reading Comprehension Scores and Vocabulary Scores	162
31. Partial Correlations: Structure Comprehension Scores and Reading Comprehension Scores with Vocabulary Scores Controlled	163
32. Comparisons of Means for Males and Females	164
33. Correlations between Structure Comprehension Scores and Reading Comprehension Scores by Sex	165
34. Raw Scores and Percent Correct Responses on the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test for Each of 83 Students	167
35. Placement of Students in High and Low Scoring Groups Based on the Median of Both Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test	169
36. Comprehension Scores of the 15 English Complex Structures of Good Readers (N = 40), Ranked from Easiest to Most Difficult	171
37. Comprehension Scores of the 15 English Complex Structures of Poor Readers (N = 43), Ranked from Easiest to Most Difficult	171
38. Comprehension Scores and Comprehension Ranks of the 15 Complex Structures for Good (N = 40) and Poor Readers (N = 43)	173
39. Spearman Rank-order Correlation Coefficient Between Good Readers' and Poor Readers' Comprehension of English Complex Structures	174
40. Most Comprehensible, Moderately Difficult and Most Difficult Ranking Structures for Good Readers and Poor Readers	175
41. English Complex Structures with Similar and Dissimilar Comprehension Ranks for Both Good Readers and Poor Readers	179
42. Comprehension Scores, Means and Standard Deviations of the Three Types of English Complex Structures for Good (N = 40) and Poor Readers (N = 43)	181
43. Summary of a Single-factor Analysis with Repeated Measures of Good Readers (N = 40) by Types of Complex Structure	182

Table	Page
44. Summary of a Single-factor Analysis with Repeated Measures of Poor Readers (N = 43) by Types of Complex Structure	182
45. Comprehension Scores, Means and Standard Deviations of the Five Complements for Good (N = 40) and Poor Readers (N = 43)	185
46. Summary of a Single-factor Analysis with Repeated Measures of Good Readers (N = 40) by the Five English Complement Structures	186
47. Summary of a Single-factor Analysis with Repeated Measures of Poor Readers (N = 43) by the Five English Complement Structures	187
48. Comprehension Scores, Means and Standard Deviations of the Five Comparative Structures for Good (N = 40) and Poor Readers (N = 43)	189
49. Summary of a Single-factor Analysis with Repeated Measures of Good Readers (N = 40) by the Five English Comparative Structures	190
50. Summary of a Single-factor Analysis with Repeated Measures of Poor Readers (N = 43) by the Five English Comparative Structures	191
51. Comprehension Scores, Means and Standard Deviations of the Five Relative Structures for Good (N = 40) and Poor Readers (N = 43)	193
52. Summary of a Single-factor Analysis with Repeated Measures of Good Readers (N = 40) by Five English Relative Structures	194
53. Summary of a Single-factor Analysis with Repeated Measures of Poor Readers (N = 43) by Five English Relative Structures	195
54. Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on Three Types of Complex Structures	205
55. Complement Structure Comprehension Scores and Percentages: Good and Poor Readers	207
56. Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on the Five Complement Structures	211
57. Comparative Structure Comprehension Scores and Percentages: Good and Poor Readers	214
58. Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on the Five Comparative Structures	219
59. Relative Structure Comprehension Scores and Percentages: Good and Poor Readers	222
60. Raw Scores and Percent Correct Responses on Right-branching and Centre-embedded Relative Sentences	226

Table	Page
61. Placement of Responses of English Relative Clauses in Pass and Fail Categories	227
62. Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on the Five Relative Structures	228

LIST OF FIGURES

Figure		Page
1.	Map of the Main Idea, Secondary and Supporting Details of the Passage from the Biology Text, "Parasitic Reproduction"	96
2.	Map of the Main Idea, Secondary and Supporting Details of the Passage from the Physics Text, "Molecular Diffusion"	97
3.	Map of the Main Idea, Secondary and Supporting Details of the Passage from the Organic Chemistry Text, "Covalent Bonds"	98
4.	Alternative Forms: Cloze Test	143
5.	Alternative Forms: Multiple-choice Reading Comprehension Test	149
6.	Number of Structures that Occurred Within the Three Comprehension Categories for Both Groups	177
7.	Comprehensibility Levels of Three Main Types of English Complex Structure (Complements, Comparatives, Relatives for Good and Poor Readers)	184
8.	Comprehensibility Levels of the Five English Complement Structures for Good and Poor Readers	188
9.	Comprehensibility Levels of the Five English Comparative Structures for Good and Poor Readers	192
10.	Comprehensibility Levels of the Five English Relative Structures for Good and Poor Readers	196

INTRODUCTION AND BACKGROUND

Importance of English Language Learning for Thai Science Students

English is nowadays firmly established as an international language of science. The bulk of research, publishing and training in scientific and technical fields makes use of the English medium. The development of new terminology to describe new discoveries, processes and inventions developed in western countries where English is used as a language of communication, is too rapid to be translated adequately into Thai for full advantages to be taken of such new knowledge. Thus one possible way for scientists from other cultures to keep up with the rapid growth of scientific and technical knowledge is through reading those scientific and technical resources in English. For Thai science students, although lectures are delivered in Thai, the greater part of basic textbook material is printed in English. They therefore need to develop reading skills in English in order to make full use of their classroom instruction. Learning to read and comprehend the English reading materials of scientific disciplines is not only an academic necessity for Thai science students but also a valuable aid in their future careers.

Situation of English Language Teaching for Thai Science Students at the University Level in Thailand

In Thailand during the last decade, a number of seminars have been conducted on English language teaching at the university level. Among them were: the Seminar on Reading, in 1970, the Seminar on the Learning and Teaching of English at the University Level, in 1974, the Seminar and Workshop on English for Science and Technology, in 1975, and the National Conference on English for Academic Purposes, in 1978. These seminars and the conference reflected an awareness of a serious problem in English language teaching, -- the failure to provide an instruction appropriate for science students to comprehend their scientific textbooks. The seminars also reflected the attempts by university administrators, English language teachers and specialists to improve the English language teaching at the university level.

To understand why Thai students do not satisfactorily comprehend their scientific texts, it is necessary to consider at least the students' English language background, their attitudes towards English language learning, the method of teaching reading in English, and the English language syllabus.

From such a perspective, one of the problems facing English language teachers at the university level, is where to start teaching English to students who come with a range of English language proficiency. The description of the situation in Chieng-mai University given by Higgins (1966) can be generalized to other universities in Thailand.

The best Bangkok schools produce students who are fluent, while country schools, which cannot attract well-qualified staff, send us boys and girls who are almost inarticulate in English
With classes of nearly fifty of widely mixed ability, one does not know what standard to teach to (p.56).

Furthermore, the science students' lack of interest in learning English is another problem facing language teachers at the university level. In the Thai school system, English is learned as a foreign language, as one academic subject. Thai students have to take English language courses for at least 8 years before entering a university. However, with a shortage of qualified English language teachers and a lack of suitable materials, most students attain a low level of English language proficiency (Sagarik, 1979; Sitachitta & Sagarik, 1976; Sukwiat, 1970). This has forced them to, in effect, start learning English over and over again as they move on to higher educational levels. Higgins (1966) again provides a good illustration of the problem:

Most of the students have had anything up to eight years of English before reaching university, but the standards of teaching at the lower levels are mixed, and the whole system consists of a series of false starts. Children start to learn English at the age of eleven and have two years in primary school. On going to high school at thirteen, they start again at the beginning to repair the faults of the previous instruction. When they enter the pre-university classes at sixteen, they once again start at the beginning of a course, learning "This is a book". When they come to university the first thing we give them is a one-term grammar revision course. Our first problem, then, is that we have students who are heartily sick of learning English and apparently never getting anywhere (p.56).

Another problem is that the English language syllabus for science students both at the pre-university level and at the university level, is

mainly literary-based and is irrelevant to the kind of English they encounter in scientific textbooks. Furthermore, most of the reading materials used in English language classes tend to be those which are either "simplified" or designed specifically for foreign language learners. After years of studying books written for foreign learners of English, science students suddenly have to study academic subjects from textbooks written for British or American university students. As a result, the Thai students find difficulty not only in understanding scientific concepts in English but also the manner of their presentation in such books.

One of the more important problems endemic in the situation is the method of teaching reading in English. What has been found in practice in English language classes both at the secondary level and at the university level, is not that the disappointing performance of students is due to their own inadequacy but rather to the performance of the teacher. Mackay and Mountford (1976) provide an illustration:

Our observations in a dozen countries indicate that the method ("explication de texte") is widespread at the advanced level of EFL/ESL instruction, (especially with university undergraduates in the sciences and technology) and is associated with the notion of intensive reading comprehension for special purposes ...

Frequently, teachers are left on their own to decide what features of the text should be explained. This results in a rather indiscriminate "going through" the passage, after an initial reading aloud, or silent reading. The procedure usually takes up a whole period, which is convenient, and a multiplicity of linguistic points may be "covered" i.e. pointed out, explained and further illustrated, during the class hour. Unfortunately, the procedure leads to something of a virtuoso performance on the part of the teacher, for which the student is required to use his ears far more than his eyes (p.8).

As such problems became apparent in the past, some attempts were made to improve English language teaching at the university level. An English language proficiency test has been developed and used to establish homogeneous classes (in terms of level of English language

proficiency), in an attempt to solve the problem of proficiency spread. This has been done at Thammasart, Khon Kaen and recently at Chulalongkorn Universities. Again the establishment of an English Language Department or English Language Centre as the sole, central authority responsible for all English language programmes for all faculties has occurred in most universities in Thailand. The advantage of having such an authority is to make the most economic use of available teaching resources including teaching staff, teaching materials and equipment. Further, to make provisions for the special needs of science students, most universities in Thailand provide opportunities for science students to take up to four courses of a "general English" language programme, followed by either compulsory or elective courses in English for Specific Purposes (ESP). Specialised ESP courses, providing instruction in English for Science and Technology (EST) for science students, have become increasingly common in most universities. Commercial ESP textbooks have been widely used. Moreover, attempts have been made, for example, at Mahidol, Chiang-mai and Chulalongkorn Universities to develop special ESP reading materials for student use.

The development of ESP programmes in the teaching of English to science students, however, is not without its problems. The lack of appropriate ESP materials suitable for Thai science students and the lack of qualified English language teachers to teach ESP still pose difficulties. Finally, the methods of teaching for reading comprehension have not yet received much attention.

Significance of the Present Study

The question of how to help improve science students' English language learning so that they can better comprehend their scientific and technical materials has been of great concern among linguists and second or foreign language specialists for over a decade. Linguists have tended to approach the problem by first investigating those characteristics of English for Science and Technology (EST) that make it distinctive. As a result, some linguists, using frequency counts, have described EST in terms of its formal properties (Barber, 1962; Cowan, 1974; Ewer & Latorre, 1967; Huddleston, 1971; Martin, 1976; McConochie, 1969; Praninskas, 1972; Puangmali, 1975; Salager, 1978; Simpson, 1965). Others have attempted to find out its rhetorical character, that is, the ways a scientist uses to communicate scientific concepts to his readers (Jones, 1974; Lackstrom, Selinker & Trimble, 1973; Mackay, 1974;

Mackay & Mountford, 1976; Selinker, Trimble & Trimble, 1976; Selinker, Trimble & Vroman, 1972, 1974; Widdowson, 1971). The assumption underlying such linguistic approaches is that if the language materials are developed on the basis of the EST characteristics, science students will learn English more effectively and be able to use it better as a tool for their study.

However, reading in ESL/EFL is a complex process. That is not appropriately covered by giving attention only to the language used in scientific texts or the ways the scientific ideas are presented. There is also need for a study which places the emphasis on science learners and the language variables in EST which science learners find difficult and which might impede their comprehension of scientific English. The linguists who have attempted to study EST characteristics have as yet displayed little interest in such matters.

On the other hand, reading researchers whose interest is in the reading comprehension of foreign language learners of English, tend to approach the problem by investigating (i) the readers' reading strategies (Hatch, 1974; Hatch, Polin & Part, 1970; Oller & Tulluis, 1973), (ii) their reading interests (Dimitrijević & Gunto, 1975; Jordan, 1975; Taiwo, 1975), (iii) the transfer of reading skills and reading habits from the first language to the second or foreign language (Al-Rufai, 1969, 1976; Clarke, 1979; Kaufman, 1968; Schleppenbach, 1978), and (iv) language variables which might relate to or affect EFL students' reading comprehension (Chatasingha, 1972; Johnson, 1972; Onrapai, 1974; Perkins & Yorio, 1974; Srivicharn, 1978; Thammongkol, 1971; Yorio, 1971). Rarely does such research deal with science students.

The assessment of the reading comprehension of ESL/EFL learners has been a topic of interest for both specialists in language testing and researchers in reading second or foreign language. Cloze technique, a word deletion process whereby words are removed from a printed passage and the student's task is to predict or identify the word which was removed and replace it, has become a powerful testing device in the area of second language learning and teaching. A great deal of research has shown that cloze technique is a reliable and valid measure of (i) overall English language proficiency for ESL/EFL learners (Aitken, 1977; Alderson, 1979; Darnell, 1968; Hinofotis, 1977; Hisama, 1977; Irvine, Atai & Oller, 1974; Oller, 1972; Oller & Conrad, 1971; Stubbs & Tucker, 1974), and (ii) general English reading comprehension (Anderson, 1976;

Crawford, 1971; Friedman, 1964; Ibe, 1975; Johnson, 1975). However, again little has been done in using the cloze technique to measure reading comprehension of science students at the university level.

If the problem of improving Thai science students' reading comprehension of scientific English discourse is to be solved, a study which at least, in part, focuses on science learners and which incorporates information from EST linguistic research into the study of science learners' reading problems needs to be conducted.

Accordingly the present study aims to provide a better understanding of the EST reading capability of Thai science students and of their comprehension of selected complex structures encountered in reading scientific English textbooks. The hope is that such a study will yield information which would be of use to language teachers, foreign language learners and textbook writers. It is hoped that the information given in this thesis would particularly help foreign language reading teachers anticipate specific areas of reading difficulty which Thai science students might encounter in reading scientific texts and therefore be better equipped to handle and perhaps overcome the problems. To foreign language learners, this information might make them aware of their own reading problems as they are related in part to the language structure. To textbook writers, the present study might offer some information which could be used as guidelines on which foreign or second language reading textbooks could be based.

Order of Presentation

This thesis is presented in seven chapters. The present one provides a general background of English language learning and teaching for Thai science students in Thailand. The problems encountered and the attempts to solve them have been described. This leads to the discussion of the significance of the study. Chapter 1 is devoted to a review of the literature relevant to the area of reading comprehension as it relates to the role of language. The chapter starts off by examining the reading process in the first language and then describes the foreign or second language reading process. As reading involves both the role of written language in the text and the readers who are language users, the next two sections focus on the linguistic research which attempted to find out the characteristics of English for Science and Technology (EST) and that research which attempted to study language variables which are involved in reading comprehension. The last part of this chapter deals with the cloze technique which is used to measure reading comprehension

of Thai science students in the present study. Chapter 2 is devoted to the research questions, hypotheses, description of subjects, the instruments, methods employed to collect data and the procedures by which the data were analyzed. Chapter 3 is concerned with the test construction. The test administration and the test results are reported in Chapter 4. Chapter 5 presents the major findings of this study. These findings are fully discussed in Chapter 6. Conclusions, implications for educational practice and recommendations for future research are presented in the final chapter.

CHAPTER 1

A REVIEW OF THE LITERATURE

Introduction

It is the purpose of this chapter to provide a background to the investigation by reviewing literature that bears on the comprehensibility of English complex structures in scientific textbooks in so far as they seem to be relevant to Thai science university students. The first section of the chapter is concerned with description of the reading process both as a first language and as a second or foreign language. The aim is to place reading in a perspective appropriate for the study. The second section of the chapter reviews attempts which have been made by linguists and language specialists in the field of "Teaching English as a Second or Foreign Language", to improve the teaching and learning of English for science students whose native language is not English. The purpose is to point out that there the emphasis has been placed more on reading at the discourse level and on textual grammar rather than on reading comprehension at the sentence level. The role of language in reading comprehension both at the paragraph level and at the sentence level is pointed out in the third section. Previous studies of sentence comprehension to be found in psycholinguistic research, reading research, English as a second or foreign language learning research and second language acquisition research, accordingly receive attention in this section. The purpose is to bring into focus differences and commonalities for research and high-light the lack of research on reading comprehension undertaken with non-native English speakers. The last section is devoted to a review of some of the literature on a testing technique to be used in the present study to measure Thai science students' reading comprehension of scientific English passages, -- the cloze technique.

Reading Process

This section of the review sets out to place "reading in a foreign or second language" in perspective. In order to achieve this purpose, descriptions on the reading process and the definitions of "reading comprehension" in the first language (English) are given initially. This is followed by the discussion of the reading process as a foreign or second language phenomenon.

First Language Reading

There have been several attempts to describe what a competent reader does in the process of converting a written message into personally meaningful terms. Most descriptions of reading in the first language imply that reading is a two stage process: that of relating the graphic symbols to sounds in the spoken language and that of extracting meaning from these graphic symbols. Levin (1970) expresses this view:

...reading may be broken into two broad sub-skills. The first is the skill of decoding the writing system to its associated language...

The second rubric of component skills in reading concerns the use of the code -- the written version of the language -- for the many uses to which reading may be put. This category includes comprehension, reading for different levels of meaning, reading for pleasure, and so forth...(p.125).

Similarly, Wiener and Cromer (1967) conceptualize reading as "a two-step process" involving first identification and then comprehension. Gibson (1976) defined reading as follows:

There are several ways of characterizing the behaviour we call reading. It is receiving communication; it is making discriminative responses to graphic symbols; it is decoding graphic symbols to speech; and it is getting meaning from the printed page. A child in the early stages of acquiring reading skill may not be doing all these things; however, some aspects of reading must be mastered before others and have an essential function in a sequence of development of the final skill (p.252).

The notion that the two stages of the reading process could be separable and that the identification of graphic symbols and their conversion to sounds in spoken language should be mastered in order to derive meanings was also discussed by Venezky, Calfee and Chapman (1970). They state:

...reading has been interpreted as the process of translating from alphabetical symbols to that form of language from which the native speaker can already derive meaning. ... In rapid, silent reading by a competent reader, translation may at times proceed from graphical patterns directly (in some sense) to meaning, especially when non-

linguistic cues are utilized: paragraph indentations, position of headings, quotations, etc. But to become a skilled speed reader, it appears that one must first pass through various stages of reading -- including those that require translation from graphical forms to spoken language (pp.38-39).

Recognition that the identification of graphic symbols and their conversion to sounds in spoken language is a prerequisite to getting meaning from the written message, is to be found in the work of several linguists (Bloomfield, 1942; Chomsky & Halle, 1968; Fries, 1963; Venezky, 1967). Bloomfield and Fries for example both tried to use linguistic knowledge to devise a method of teaching reading based on a belief that children had to learn sound symbol relationships in order to read. For Bloomfield (1942), learning to read was a matter of understanding the spelling system of English, as distinct from learning what words and sentences mean. The Bloomfield approach is therefore based on the introduction of regular sound-symbol or phoneme-grapheme correspondences so that children can acquire the fundamental understanding necessary for reading, the understanding that writing is a representation of speech, and, on the whole quite a systematic one.

Fries (1963) emphasized the recognition of both the contrast between whole words and ability to sound out the letters of single words. This method was known as a "whole-word" method. Like Bloomfield, Fries had very little to say about comprehension. Both researchers apparently regarded comprehension as a basically passive activity which is highly dependent on oral language skills. Venezky (1967), like Bloomfield and Fries, was concerned with the relationship between letters and sounds. However, Venezky saw that relationship as being much more complex. He attempted to construct a set of rules for translating orthographic symbols into speech sounds. His work attempted to construct a model of the reading process which recognized the distribution of phonemes and graphemes, the frequencies of occurrence, and the patterns of correspondences. Like Venezky, Chomsky and Halle (1968) proposed two sets of rules to display the correspondences between spelling and sound (i) print-to-lexical and (ii) lexical-to-phonetic. The second relationship differs from that discussed by Venezky because the phonemic level is eliminated. For Chomsky and Halle, the lexical-to-phonetic rules are part of the automatic system of speech, therefore learning to read ought to consist of learning the apparently quite regular correspondence between orthographic and the lexical forms.

It is obvious that earlier studies of the reading process paid very little attention on the comprehension aspect. Meaning was assumed to be available primarily through language as it occurs in the auditory form. Venezky et al. (1970) clearly pointed out this notion:

In the letter-by-letter model, one can also imagine at least two ways in which comprehension could be handled. On the one hand, the visual pattern may be associated directly with its semantic referent so that, during decoding, comprehension takes place simultaneously with pronunciation. Comprehension and articulation would be more or less independent. The reader might make a decoding mistake and pronounce the word incorrectly, although understanding quite well what it meant. On the other hand, he might wait until the decoding process was complete and use the spoken representation of the word (or some equivalent thereof) for comprehension. The word would be comprehended only after it was pronounced (p.41).

Similar point of view was expressed by Wiener and Cromer (1967) who stated that:

We also have assumed implicitly that once there is a transformation from the visual to the auditory form, comprehension would follow ... (p.638).

Recently "comprehension" -- the second stage of the reading process has been attracting attention. Reading is viewed not only as decoding of graphic symbols but most importantly as decoding of meaning. Goodman (1973a) commented that one may think of reading as matching oral units with written units and then label this operation as decoding but "decoding" is a process of going from code to message in information theory (p.163). Smith (1971) clearly pointed out that "reading for meaning" entails making use of information simultaneously at both the surface and deep structure levels of language, using elements of both visual and semantic information (p.207). He makes a distinction between "mediated meaning identification", involving the identification of individual words before comprehension of a meaningful sequence of words as a whole, and "immediate meaning identification" which goes directly from graphic feature discrimination to the identification of meaning (p.206). For Wardhaugh (1969), "reading is not a passive process, in which a reader takes something out of the text without any effort or merely recognises what is in the text" (p.133).

To illustrate his point of view, Wardhaugh (1969) described what a person does while reading:

When a person reads a text, he is attempting to discover the meaning of what he is reading by using the visual clues of spelling, his knowledge of probabilities of occurrence, his contextual-pragmatic knowledge, and his syntactic and semantic competence to give a meaningful interpretation to the text(p.133).

Wardhaugh (1969) concluded that "reading is instead an active process, in which the reader must make an active contribution by drawing upon and using concurrently various abilities that he has acquired" (p.133). This view of reading as an active process is also shared by other educators and psycholinguists (Goodman, 1976; Ryan & Semmel, 1969). Goodman (1976) sees reading as a psycholinguistic guessing game which involves an interaction between thought and language. He describes the reading process as follows:

Reading is a selective process. It involves partial use of available minimal language cues selected from perceptual input on the basis of the reader's expectation. As this partial information is processed, tentative decisions are made to be confirmed, rejected, or refined as reading progresses (p.498).

Ryan and Semmel (1969) consider reading as a language process. They state:

Reading, like speaking and listening, can be considered as a language process. It is not only a matter of sequentially pairing visual forms with auditory forms which are then interpreted like speech, but rather, it is a constructive, active process in which the reader uses his cognitive and linguistic knowledge to reproduce a probable utterance from a careful sampling of cues and then matches that prediction for appropriateness (p.81).

According to Goodman (1973b) there are three types of cues which the readers of English utilize simultaneously: graphophonic, syntactic and semantic. Goodman (1973b) explains:

...The starting point is graphic in reading and we may call one cue system graphophonic. The reader responds to graphic

sequences and may utilize the correspondences between the graphic and phonological systems of his English dialect

The second cue system the reader uses is syntactic. The reader using pattern markers such as function words and inflectional suffixes as cues recognizes and predicts structures. Since the underlying or deep structure of written and oral language are the same, the reader seeks to infer the deep structure as he reads so that he may arrive at meaning.

The third cue system is semantic. In order to derive meaning from language, the language user must be able to provide semantic input. This is not simply a question of meaning for words but the much larger question of the reader having sufficient experience and conceptual background to feed into the reading process so that he can make sense out of what he's reading (p.25).

It must be admitted that there are many definitions of reading, from the simple decoding process to the most complex process involving all past experience (Mackworth, 1972). Despite various views of what reading is, a point on which educators, psychologists, linguists and psycholinguists agree is that reading is a very complex process.

Foreign or Second Language Reading

Reading in a foreign or second language however, is even more complex. Yorio (1971) discussed in full detail problems the foreign language reader encounters:

When reading in a foreign language,

(1) the reader's knowledge of the foreign language is not like that of the native speaker; (2) the guessing or predicting ability necessary to pick up the correct cues is hindered by the imperfect knowledge of the language; (3) the wrong choice of cues or the uncertainty of the choice makes associations more difficult; (4) due to unfamiliarity with the material and the lack of training, the memory span in a foreign language in the early stages of its acquisition is usually shorter than in our native language; recollection of previous cues then, is more difficult in a foreign language than in the mother

tongue; (5) at all levels, and at all times, there is interference of the native language (p.108).

A similar view on the ability of the first and foreign language readers to predict the cues necessary for comprehension of the material was also expressed by Elias (1975). In her words:

It was found that native speakers of English "tend to ignore grammatical markers" and pay much more attention to content words than do foreign students (Hatch, 1973:5). This would seem to indicate that native speakers of English are able to supply these grammatical markers from their knowledge of the language; whereas second language learners are not. In other words, native speakers have the ability to predict syntactic markers. This is something that the foreign student lacks; so he/she must pay closer attention to the structure words

In addition to this intuitive knowledge of the syntax of English, native speakers have the advantage of knowing lexical associations. Since these associations are partly conventional in a culture, native speakers are better able to anticipate lexical items that are likely to occur together in a particular context. Not only are native students better than foreign students at predicting syntax and vocabulary, they also have the advantage of being familiar with cultural contexts. This experiential predictability makes it possible for them to anticipate at times even the substance that is likely to follow in a given context (pp.307-308).

Plaister (1973) also pointed out that the most obvious differences between the native reader and the non-native reader is the reader's knowledge of the language and his knowledge of the culture he is reading about (p.31).

Although first language readers and foreign or second language readers differ in their abilities to use language cues, both are considered as language users. Reading for them has the same aim which is to achieve meaning from the text (Davies, 1979). Eskey (1973) goes further and considers that first and foreign language readers process information from the text similarly. Within the reading framework developed by Goodman (1976) and Smith (1971), Eskey (1973) explained how "any" reader

processes information. In his words:

..... he must process information at three levels simultaneously. There is first the outer layer of the printed page itself, the bundles of letters to be deciphered; then, at one remove, there is the level of abstract form, which in the case of reading includes both rhetorical form, the structure of the text, and linguistic form, the structure of the sentences, phrases, words; and there is finally the inner level of meaning, both the meanings of the separate linguistic forms and the cumulative meaning of the passage as a whole (p.174).

Reading in a foreign or second language has been generally accepted as a language process. It is believed that the ability to crack the appropriate linguistic codes is essential for non-native readers in order to ascertain the real meaning of a message (Cowan, 1974; Eskey, 1973, 1975; Pierce, 1973; Plaister, 1973). Mackay and Mountford (1976), in an attempt to define the notion of "teaching reading comprehension" in a foreign language class, pointed out that most EFL/ESL students have already acquired the skill of reading with comprehension and have frequently practised it in their own mother tongue. Accordingly, "what we teach", Mackay and Mountford (1976) stated, "is not the ability to read, nor really the ability to comprehend, but the strategies that will enable the transfer of skills already acquired in the mother tongue to interpret meaningfully the syntactic, semantic and rhetorical patterns of L2 (second language)" (p.10). For Mackay and Mountford (1976), the ability of the student to comprehend a foreign or second language depends upon:

- (a) his having acquired a knowledge of many (if not most) of the rules governing the language system (i.e. its syntax),
- (b) his having built up a large enough store of vocabulary meanings and relationships (i.e. the semantics of the language), and (c) his having become accustomed to the ways in which the language's syntactic and semantic properties are exploited in the creation of meaning in actual communicative use (p.10).

Wardhaugh (1976), in the discussion of reading technical prose, described the reading process as follows:

.... reading is active, interactive, productive, and cognitive. It involves an active search for information and interaction with the text; it requires the constant constructive involvement of the reader in what he is doing; and it demands the use of higher order mental abilities (p.92).

To Wardhaugh (1976) three factors are relevant for the successful reading of technical prose -- the reader's knowledge of subject matter, his knowledge of language -- vocabulary, syntax, discourse, and his reason for reading.

The reading process in English as a foreign or second language has been recently viewed as an active, selective process in which meaningful information is contributed more by the reader than by the print of the page (Clarke & Silberstein, 1977; Eskey, 1973; Moody, 1976). This standpoint, influenced by Goodman's reading model has led to an emphasis being placed on developing in the non-native reader the ability to make predictions as to meaning on the basis of syntactic, semantic and rhetorical clues picked up and accommodated during the reading process (Elias, 1975; Mackay & Mountford, 1976; Moody, 1976; Pierce, 1973, 1975).

Conclusion

Reading in native language is a complex process. It has been defined as a two-stage process: that of relating the graphic symbols to sounds in the spoken language and that of extracting meaning from these graphic symbols. There has been some disagreement on the relationship of these two stages of the reading process. Reading, for some linguists, psycholinguists and educators, has been defined as a simple decoding process from graphic symbols to sounds. For others, reading has been defined only when comprehension occurs. Recent reading models consider reading as an active process where a reader must contribute in order to ascertain the meaning from text.

The reading process both in a native language and in a foreign or second language has been considered similar. However, a reading task for a non-native reader is more difficult because of his lack of knowledge of the language. Influenced by the reading framework developed by Goodman (1976), reading in English as a foreign or second language has been recently considered as an active, selective process where a reader must actively utilize productive cues to make the print meaningful to him.

For the purpose of the present study, reading in English as a foreign language will be viewed as an active, selective, language process, which involves the active contribution from the reader in order that a written message will be meaningful to him. It is a process in which the reader has to utilize three kinds of information simultaneously -- graphophonic, syntactic and semantic (Goodman, 1976).

This section has examined the notion of what reading is. The next section will focus on the role of linguistic research on reading in English for Science and Technology.

Linguistic Research on English for Science and Technology (EST)

This section describes the part that English plays in science education at the tertiary level, and reviews linguistic research which deals with English for Science and Technology.

English Language Teaching and English for Special Purposes (ESP)

For the last ten years, the teaching of English as a foreign language (TEFL) and as a second language (TESL) for science and technology students, has become more widely known as "English for Special Purposes" (ESP). The term is generally used to refer to the teaching of English with a clearly utilitarian purpose. The purpose can be vocational or occupational training or for academic or professional study (Mackay & Mountford, 1978). Accordingly there have arisen various terms to describe specialized applications, for example, "English for Vocational or Occupational Purposes" (EOP), "English for Academic Purposes" (EAP), "English for Science and Technology" (EST). Such ESP courses, although they are different for each specific purpose, reflect the same reaction against traditional literary-oriented TEFL or TESL courses previously provided. Strevens (1977) describes this reaction:

They (special-purpose courses) represent, in fact a reaction against conventional foreign-language instruction as part of the humanistic segment of a general school education, in which the unspoken assumption is made by both learner and teacher that the target for achievement is "the whole of" the foreign language (p.145).

The literary-based TEFL or TESL courses have proved insufficient for the needs of science students whose purpose in learning English is to pursue their studies in the field of Science and Technology (Cooper, 1976; Pittman, 1957; Strevens, 1971; Swales, 1973). The shortcomings of these courses were due to (i) the literary basis of the English language syllabus (Bartolić, 1962; Bates & Dudley-Evans, 1974; Garwood, 1970; Macmillan, 1971), (ii) the traditional orientation of the English language teachers who were called upon to teach English for the use of scientists (Harrison, 1973; Macmillan, 1971), and (iii) the use of teaching methods which placed primary emphasis on speech, regardless of the aim in language learning (Corbluth, 1975).

Three factors seem to have contributed to the rapid growth of the current ESP programmes: (i) the shortcomings of the traditional TEFL and TESL courses, (ii) the new trend in educational thought which focused attention rather upon the learner and upon ways of optimising his learning (Strevens, 1977) and (iii) the important role of English as the principal international language of Science (Ewer & Latorre, 1967; Farrokhpey, 1970; UNESCO, 1957).

As Pritchard and Chamberlain (1974) point out:

In recent years profound changes have occurred inside the subject once known so simply as "English". Revitalized thinking in psychology, linguistics and sociology has led to re-orientation in methodology, while the more pragmatic forces of economics and politics have affected the functions of English throughout the world.

Of the many changes that have taken place, the central one is probably the movement towards the teaching of English as an international medium of communication in such fields as commerce, industry, science and technology. This revised definition of the role of English has usually replaced an older tradition in which English was the language of education, of colonial culture, and of governmental administration. It has given rise to such acronymic variations as ESL, EFL, ESP and EST (p.48).

It is the area of EST, a major sub-division of the field of teaching English for Special Purposes (ESP) which is of concern in the present study.

Linguistic Research on English for Science and Technology (EST)

Most of the studies of English for Special Purposes (ESP) have been concerned with English for Science and Technology - due to the great demand from science and technology students to learn English to keep up with advanced knowledge in their fields (Ewer & Latorre, 1967; Harrison, 1973; Pittman, 1957; Smithies, 1976; Strevens, 1973). Their specific need to learn English, especially in a foreign language situation however, was and is mainly to read technical and scientific materials (Bates & Dudley-Evans, 1974; Cooper, 1976; Dudley-Evans, Shettlesworth, & Phillips, 1975; Mackay & Mountford, 1978). Because of this, linguists and language teachers have come to attempt to study vocabulary, syntactic structure and discourse aspects of Scientific English writing in order to establish the characteristics of EST. In the following discussion, EST linguistic research will be grouped according to the approaches used in studying EST.

Lexical analysis

Influenced by the notion of "register" defined as "formally differentiated and distinct sub-codes of a particular language" (Mackay & Mountford, 1978), a group of researchers has tried to differentiate EST from other varieties of English by studying its lexical properties. Frequency counting (one of the criteria for the selection of useful linguistic units for language learning purpose) was widely accepted in these lexical studies. Investigation of science textbooks at the secondary school (Curtis, 1969; Powers, 1962) and university level (Martin, 1976; Praninskas, 1972) yielded frequency lists of vocabulary common to all scientific disciplines. Cowan (1974) undertook a similar study of medical vocabulary in medical journals, and Puangmali (1975) compiled a list of technical and non-technical terms along with their frequency and range, especially for engineering students in an English as a foreign language situation. Puangmali's list was drawn from a corpus of ten texts representing five major areas of technology including chemical engineering, computer science, electronics, surveying and traffic engineering. His word list also included words with a low frequency of occurrence. Another engineering vocabulary list was compiled by Salager (1978) who attempted to define the specific characteristics of technical English literature. Salager's list was drawn from a corpus of 100,000 words consisting of fifty sample-texts of 2,000 words each. These sample-texts were randomly selected in

engineering literature. Salager, in her study, identified three kinds of technical vocabularies (i) Basic English, (ii) Fundamental Technical English, and (iii) Specialized Technical English.

The lexical studies on scientific writing mentioned above have been conducted at three levels -- ordinary language level, semi-technical language level, and scientific language level. Ordinary language encompasses basic or common vocabulary, that is, function words and content words that carry a general meaning. This vocabulary has proved to be very difficult for non-native English scientists (Smithies, 1976). Semi-technical language refers to context independent words which occur with high frequency across disciplines (Cowan, 1974). This level is also a problem one for foreign learners (Cowan, 1974; Herbert, 1965). By contrast, words belonging to a particular science or technical subject, have proved to be the easiest for non-native English scientists (Smithies, 1976). The meanings of specialized technical vocabulary can apparently be readily picked up while learners are studying the discipline which uses them. Even so, vocabulary has been found to constitute one of the major reading problems for non-native English speakers (Cowan, 1974; Eskey, 1975; Flood & West, 1950; Pittman, 1957; Siripol, 1979; Smithies, 1976; Sopher, 1974; Yorio, 1971). Understandably the problem has received a great deal of attention from linguists and educationists. In practice, vocabulary seems easier to learn for non-native English speakers than are syntactic structures or Scientific English discourse.

Syntactic analysis

Under the same notion of "register", empirical research has been undertaken into the frequency of occurrence of English syntactic structures in scientific writing. These syntactic studies, influenced by different schools, investigated the language of science at different textbook levels. Accordingly conclusions varied. However the information obtained served the same two purposes, it provided: (i) a basis for grading the language materials for the teaching of science students and (ii) a list of teaching points.

The systematic observation of the frequency of occurrence of syntactic structures was first made within the framework of the Structural Grammar approach. Several frequency count studies of English syntactic structures of technical prose based on the concept of structural linguistics, were made by Barber (1962), Ewer and Latorre (1967),

McConochie (1969), and Simpson (1965). Barber (1962) conducted a small scale study with the specific aim of examining the characteristics of modern Scientific English. The data were taken from three standard university textbooks representing six different scientific fields - electronics and engineering; biology and chemistry; astronomy and instrumental optics. Two areas of grammatical construction were examined: sentence structure and verb forms. The results revealed that the "simple sentence" was the commonest sentence type and "adjective clauses" were the largest single type among all subordinate clauses in the sample. For the verb forms, the "present simple active" was found to be the predominant tense followed by the present simple passive. Of the non-finite verbs, the largest group was the -ing form. Similar high frequency use of "the present simple tense" and of "passive forms" was also found by Ewer and Latorre (1967). Their data, however, were drawn from different levels of technical materials, ranging from "semi-popular", introductory university textbooks, advanced textbooks, to specialized articles, professional papers and monographs.

Simpson's (1965) study, using the method of descriptive linguistics, analyzed scientific writing in English to discover characteristic structures. These structures were compared in frequency. Their patterns were also compared with others from general writing so that the grammatical constructions of scientific writing which might distinguish it from general writing could be discovered. Representative structures of scientific writing were extracted from 60 papers. prepared for symposia principally in metallography, friction and fluid phenomena, chemistry and nuclear physics. The structures of ordinary writing were drawn from quantitatively equal materials of a general non-fiction character. The findings revealed that scientists select more simple sentences using noun and intransitive-verb or noun and linking verb patterns than do general writers. They prefer complex sentences and transitive-verb patterns taking direct objects (Simpson, 1965, p.164). Simpson also found that noun unit modifiers occurred twice as often and group qualifiers containing nouns 20-percent more often in the technical than in the general materials. Highly characteristic of pronoun occurrences were the third-person impersonal "it" and the demonstrative pronoun "this". The passive predicates accounted for 50 percent of all transitive verbs used in the technical writing but represented only about 10 percent of those used in non-fiction.

In the final study to be reviewed in this section, McConochie (1969) examined (i) the frequency of occurrence and (ii) the sentence-level use of syntactic structures in civil and electrical engineering textbooks. The primary sample consisted of 2,000 sentences (approximately 46,000 words) from 100 engineering texts. A control sample of 919 sentences (approximately 23,000 words) was drawn from contemporary American literary prose, as represented in anthologies compiled for use in undergraduate English courses for native speakers. The data were coded in terms of sector analysis, a tagmemic (slot-and-filler) grammar in which:

... the primary emphasis is upon the different kinds of positions that are to be found in English sentences, and on the different kinds of units that may occupy one or another position. It is assumed that every sentence consists of a string of potential positions for different kinds of constructions, although in any given sentence one or more of these positions may be unoccupied, each of these constructions, in turn, consists of a string of positions for different kinds of units, on a lower level (Allen, 1964, p.23).

The results of the study revealed that engineering writing uses a smaller subset of the total inventory of grammatical constructions in English than does literary writing. The modal pattern is subject, passive verb, complement, with the subject position filled by a cluster and the complement position by a prepositional phrase.

However, the structural grammar approach which provided the theoretical framework for the above studies proved inadequate to reveal the complexity inherent in scientific writing. This is because the major emphasis of structuralism is on the form of sentences and their parts, not on their deep meaning. Accordingly, it fails to provide a satisfactory explanation of the relationship between two sentences which have different surface structures but which contain the same meaning. Chomsky's generative-transformational grammar (1957, 1965) has provided researchers with a precise method of representing syntactic operations (i.e. transformations) in language. With its set of explicit syntactic rules, the generative-transformational grammar helps to clarify otherwise intuited relationships among sentences and to detect (i) synonymy resulting from identity deletion, (ii) synonymy

resulting from deletion of indefinite elements, (iii) ambiguity (Lee, 1975). Huddleston (1971), using generative-transformational grammar as the theoretical framework, investigated grammatical constructions of scientific English specifically, mood, transitivity and voice, complementation, relativization, comparison, the modal auxiliaries and theme. His corpus consisted of some 135,000 words of written scientific English, derived from 27 texts of 5,000 words each. The texts were taken from three different "strata". Nine "high" stratum texts came from specialist journals and nine "mid" stratum ones from undergraduate textbooks. The high and mid texts were classified according to field or subject matter, namely, biology, chemistry and physics. Nine "low" stratum texts came from more popular works addressed to the intelligent and well-informed layman. Huddleston (1971) reported the findings on subject and object complementation in the corpus that:

... with finite clauses object function was almost five times as frequent as subject, with non-finites there is not very much difference in frequency between object and subject complements ... (p.180).

When the to-complementizer was compared to the ing-forms, it was found that the to-complementizer was about 30 times the more frequent (Huddleston, 1971, p.180). Restrictive dependent relative clauses with the relative pronouns that (325) and which (482) were seen to form the majority of the examples of dependent relative clauses (965 examples). Among comparisons of inequality, Huddleston (1971) found that the more -er less comparatives without than occurred most frequently (484 out of 631 examples).

Cowan's (1974) analysis of syntactic structures was totally based on the framework of the generative - transformational grammar. His corpus consisted of 1,500 sentences compiled from different medical texts used at the University of Teheran. The study aimed to provide accurate information about the syntactic style of medical prose so that it would help teachers in selecting the structures to be taught and indicate which structures tend to occur frequently and with other structures.

One of the major reading problems facing non-native English speakers at the advanced level has proved to be their inability to cope with syntactic structures (Eskey, 1970, 1973, 1975; Nilagupta, 1977;

Pierce, 1973; Siripol, 1979; Sopher, 1974). The studies reviewed above have provided some interesting information on syntactic structures of scientific English in terms of relative frequency of occurrence. However, their immediate aim was purely descriptive. Linguists offered little information which could help determine how certain syntactic structures found in scientific English should be taught so that they would become more comprehensible for foreign science students. If the teaching of reading comprehension is to be improved, the knowledge of the frequency of occurrence of syntactic structures in scientific writing only is not enough. There is also a need to investigate specific problems which might deter non-native English science students from understanding.

Discourse analysis

Attempts to investigate EST at the discourse level were made by Lackstrom, Selinker, Trimble, Vroman, Mackay and Mountford. Lackstrom, Selinker and Trimble (1973) approached EST by studying its rhetoric in terms of "conceptual paragraph" as well as its rhetorical functions such as definition, classification, explanation, description and argument. Rhetoric in EST has been defined as the process employed to produce a desired text. This process is basically the act of organizing scientific and technical information for specific purposes and for specific types of readers (Trimble, 1977). The notion "conceptual paragraph", a basic unit of scientific discourse, was explained thus:

It contains, or clearly implies, a generalization, which we shall call the "core generalization". This core generalization, if stated in the EST text, is usually found in the first sentences of the paragraph. It may be stated as a separate sentence, or it may be rhetorically embedded in adjoining sentences. This core is developed by supporting information which ranges from dependent generalizations, that is generalizations on a level lower than that of the core, to very specific statements ...

It is our contention that in EST the conceptual paragraph is the basic unit of discourse, and that it can be equivalent to one or more physical paragraphs (Lackstrom, Selinker, & Trimble, 1973, pp.129-130).

By contrast, the physical paragraph is defined as a group of sentences marked on a page of text by spacing or indentation (Lackstrom et al. 1973, p.130). Lackstrom et al. (1973) suggests that a conceptual paragraph may function to report past research, to discuss theory, to state purpose, to describe apparatus, to explain an illustration, to state a problem, and that these rhetorical functions affect the surface grammatical forms of articles and tenses.

The inabilities of advanced non-native readers of EST to comprehend the total meaning of the EST discourse, even when they understand all the words in each sentence and all the sentences that make the discourse, led Selinker, Trimble and Trimble (1976) to assume that this was because they did not possess those abilities which would allow them to recognize the existence of the types of presuppositional rhetorical information that were implicit. Further investigation into implicit rhetorical functions within a particular piece of discourse (specifically, implicit definition and implicit classification) was therefore undertaken (Selinker, Trimble, & Trimble, 1976). As a result, it has been discerned that defining and classifying information presented implicitly does not usually function as the core generalization or part of the generalization of an EST paragraph. Rather, it functions as the information which is supporting the generalization (p.285). They have also discovered that implicit defined and classified information affected the usages of articles and tenses in EST discourse.

As a result of the above studies, a "rhetorical approach" to the teaching of reading to advanced non-native readers of EST was proposed. It entails the teaching of the notion "conceptual paragraph", emphasizing "rhetorical functions" of the conceptual paragraph presented both explicitly and implicitly (Selinker et al., 1976), and dealing with the "informational clues" which are presented in the form of key terms which indicate causality, comparison, contrast, analogy etc.

The role of semantic, syntactic and rhetorical clues has been the area of interest in studies by Mackay (1974) and Mackay and Mountford (1976). These researchers view reading comprehension at the discourse level as involving the perception and interpretation of linguistic signals which make up the grammatical cohesion of text and the communicative cohesion of discourse (Mackay, 1974). They believe that such linguistic knowledge as lexical relationships, syntactic

relationships and logical relationships is required for a reader to have adequate comprehension of the text. In this respect, lexical relationships were considered in terms of "lexical inclusion" or "hyponymy" and "equivalence" or "synonymy". Syntactic relationships between sentences included anaphora (backward reference) and cataphora (forward reference). Logical relationships between sentences or stretches of text included logical connectors like moreover, so, as a result, and (Mackay, 1974).

To Mackay and Mountford (1976), teaching reading comprehension to advanced non-native readers of EST, means to help them develop a reading strategy which includes the ability to recognize such linguistic signals.

Studies at the discourse level have produced some useful and promising information for the teaching of reading comprehension to non-native English speakers. The studies, however, were conducted on the assumption that readers already possessed the ability to comprehend at the sentence level, and that the rhetorical problem is the only one being faced at the time. Furthermore, information on the rhetorical approach was mainly based on the analysis of scientific writing. More data from reading research is needed to show that the approach actually does improve the reading strategies of non-native English science students, and in turn helps them improve in their reading comprehension.

Conclusion

This part of the review has been concerned with linguistic studies which have investigated English for Science and Technology; at the lexicon level, the syntactic structure level and at the discourse level. Although these studies took different approaches in studying the EST characteristics, they shared the same objective, that is, to provide a basis for the development of the teaching materials which would suit foreign science students' need. However, to help science learners improve their reading proficiency in English, it is also necessary to focus on their reading problems. A primary concern of the present study is such problems. Accordingly, the review in the next section will be devoted to the role of language in reading comprehension.

Research on Language Structure and Reading Comprehension

Unlike the productive skills -- speaking and writing, reading comprehension, a receptive skill, is inaccessible to direct observation. Simons (1971) described the products and processes of comprehension:

The comprehension process is the mental operations which take place in the reader's head while he is reading. These operations are generally not observable and not open to introspection. On the other hand, the products of the comprehension process are the behaviors produced after comprehension has taken place, such as answers to test questions (p.340).

Because reading comprehension is a very complex process and is not directly observable, many different approaches to understanding the reading comprehension process have been attempted, often reflecting different perspectives.

The review of research on reading comprehension to be undertaken here will be limited only to that research which investigated reading comprehension in relation to language structure. It involves (i) those studies which attempted to see if the relationship between reading comprehension and the knowledge of English grammatical structures exist, (ii) those readability studies which investigated language variables in the written language, (iii) those psycholinguistic studies and second language acquisition research which investigated sentence comprehension.

Knowledge of English Grammatical Structures and Reading Comprehension

The assumed notion that there is a relationship between knowledge of grammar and reading comprehension has been investigated in several studies (Gibbons, 1941; O'Donnell, 1963; Sauer, 1969, 1970; Shackford, 1976; Strom, 1956).

Gibbons (1941) administered a battery of tests to a group of 25 third grade children. A disarranged phrase test was used to measure ability to see the relationship between parts of a sentence and sentence completion and question tests were used to measure the ability to understand the sentences used in the disarranged phrase test. As well the Gates Standardized Reading Test was used to determine reading achievement, and the Terman Revision of the Simon

Binet Intelligence Test was used to determine the mental abilities of the group. The findings revealed that there was a positive correlation between (i) ability to see the relationship between parts of a sentence and ability to understand the sentence ($r = .889$), (ii) ability to see the relationship between parts of a sentence and scores on the standardized reading test ($r = .717$).

Ability to see the relationship between parts of a sentence was also investigated in a number of other studies. Taking a structural approach to English grammar, O'Donnell (1963) analyzed grammatical structures in terms of certain basic relationships within the sentence (the subject-verb relationship; the verb-complement relationship; the relationship between coordinate elements; the relationship between the various types of modifiers and elements modified; the relationship between elements involved in cross-reference). A test consisting of 50 items of the multiple response type was constructed to measure the ability to recognize these structural relationships. Test C1: Reading Comprehension, Form Z was used to measure reading comprehension. The Iowa Grammar Information Test, Form A was used to measure the ability to verbalize grammatical rules and terminology. These tests were administered to 101 students from a senior class. The correlation coefficient between the structure test scores and level of comprehension scores was $r = .44$. O'Donnell concluded that the relationship was not significant enough to warrant the teaching of grammatical structure as a major means of developing reading comprehension.

Sauer (1969, 1970) constructed sentences using a nonsense language called Boingue to match four basic sentence patterns. These sentences varied according to three levels of structural complexity. One hundred and fifty-three fourth graders were asked to translate sentences such as "A boing boinged our boing" into English sentences. Their responses to the test of grammatical structures and the paragraph meaning sub-test of the Stanford Reading Test, Intermediate I, were collected and analyzed. The correlation coefficient between the total grammar test and reading comprehension was $r = .64$. When multiple regression analysis was applied, the relationship between predicted and criterion scores was $r = .67$. Sauer concluded that there was a predictive relationship between reading comprehension and knowledge of total sentence patterns, in combination.

Shackford (1976) investigated the knowledge junior high school students had concerning the basic structure of their language and tested whether their knowledge of grammatical structure was related to reading comprehension. An English Language Structure Test was developed to measure the ability to recognize basic structural relationships in English sentences. This was done by scrambling sentences in a manner that disguised the meaningful relationships of the words to each other. The scrambled sentences were constructed to match six basic sentence patterns and varied in their level of complexity. Two hundred and two, seventh and eighth graders were asked to reorder the scrambled sentences to resemble logical English sentence order. The Advanced Stanford Reading Test, was also administered to measure ability in reading comprehension. The study revealed that there was a relationship between the students' knowledge of grammatical structure and ability in reading comprehension. The correlation coefficient ($r = .67$) was reported to be significant. Shackford also found that junior high school students' knowledge of six total sentence patterns differed significantly by sentence pattern, and that students in grade eight demonstrated greater knowledge of grammatical structure.

Strom's study (1956) was also concerned with the relationship between English grammatical structure and reading comprehension. In investigating this relationship, Strom constructed a test battery consisting of 10 literary or informative passages of vocabulary and of the grammar of the sentences composing the reading passages. Three hundred and twenty-seven sophomores in the 15 classes chosen from 10 public and private high schools in eight states were involved in the study. The significant correlation coefficients between reading and grammar were $r = .57$ for the public schools and $r = .39$ for the private schools. Strom suggested that an experimental study, utilizing experimental and control groups, was needed to show specifically how grammatical analysis might be used to improve reading.

Several other studies reported substantial correlations between the knowledge of English grammatical structures of native speakers of Thai and their reading comprehension. A case study was conducted by Thammongkol (1970) who investigated the reading ability of 40 Thai students at the university level (20 art students and 20 engineering students). She found that the relationship between the skill in

English and the effectiveness of expression and the ability to read was $r = .62$ for art students, and $r = .64$ for engineering students. Among several suggestions for further research, Thammongkol stressed the need for studies of the relationship between knowledge of English grammatical structures and reading comprehension at various levels (p.193). Following Thammongkol's suggestion, a study was conducted to investigate the reading comprehension of 310 students at the teachers' college level (Chatasingha, 1972). Chatasingha found that the students' reading comprehension correlated with their knowledge of grammar ($r = .63$) and of vocabulary ($r = .91$) at the .01 level of significance. Another study was conducted to 200 students at the lower secondary level (Onprapai, 1974). By administering a 70-item grammatical structure test and a 35-item reading comprehension test, she achieved a correlation coefficient of $r = .76$ between knowledge of English grammatical structures and reading comprehension. A similar result was achieved by Charoensook (1974) who administered a grammar test, a vocabulary test, and a reading comprehension test to 180 Thai science students at the upper secondary level. She found significant positive correlation coefficients of $r = .69$ between reading comprehension and knowledge of English grammatical structures, and of $r = .53$ between reading comprehension and vocabulary. Charoensook pointed out that half of the subjects in her study found the following structures difficult to use; the passive voice, pronouns, comparison of adjectives and adverbs, and relative clauses. Further study which investigated the difficulty of English grammatical structures for Thai vocational students was conducted by Srivicharn (1978). A 50-item English Syntax Comprehension Test was developed to measure comprehension of five different features of English syntax. They were the passive voice, embedding, negation, nominalization and deletion. One hundred and twenty students from three campuses of the Institute of Technology and Vocational Education in Bangkok were involved in the study. A correlation coefficient of $r = .87$ was achieved between English syntax scores as measured by the English Syntax Comprehension Test and reading comprehension scores as measured by a 35-item Cloze Reading Comprehension Test. The difficulty levels of the five features of English syntax ranked from the most difficult to the easiest, were passive voice, embedding, negation, nominalization and deletion.

The results of most of the reviewed studies support the notion that there is a relationship between the knowledge of grammar and

reading comprehension for both native and non-native English speakers. The studies reviewed however, focused on reading comprehension of general English reading materials rather than scientific English textbooks. The subjects were tested on their knowledge of English grammar usage rather than on their understanding of English grammatical structures. Moreover, these studies generally involved non-science students. The results therefore can not be generalized to those students whose interest is in science.

Readability and Sentence Structure

Some attempts at studying reading comprehension by isolating certain linguistic features which were thought to affect the difficulty of the sentence or the passage have been undertaken in the name of readability research. The aim of the readability studies is to improve the readability of written language.

Traditional readability research has tended to be concerned with assessing grammatical complexity based on sentence length. Sentence length has been measured using various units of analysis - letters, syllables or words. In readability formulas, sentence length, as a readability factor, appears to be the one linguistic variable most preferred in many of the more widely used formulas for predicting the reading difficulty level of a prose (Dale-Chall, 1948; Flesh, 1948; Lorge, 1939; Spache, 1953). The validity of sentence length as a readability factor, however, was questioned by Strickland (1962). In conducting an investigation to determine whether there was a correlation between the language of children and the syntactic patterns used in children's books, Strickland established a system for analyzing language. The results of the analysis of the oral language patterns of 575 children of grades 1 through 6 indicated that some syntactic patterns had high frequencies of occurrence and some had low. An analysis of the language in four sets of textbooks showed that "there appeared to be no scheme for the development of control over sentence structure which paralleled the generally accepted scheme for the development of control over vocabulary" (Strickland, 1962, p.104). The finding led Strickland to raise the question as to whether the sentence structure in children's books influences the difficulty of learning to read. Strickland suggested that tests of difficulty of patterns of syntax should be included in formulas for measuring readability. Other researchers (Hunt, 1965;

Loban, 1963; O'Donnell, Griffin, & Norris, 1967), in finding sentence length an inadequate measure of difficulty, followed Strickland's suggestion and developed new ways to segment language. Hunt (1973) found that "Clause length is a better index of language maturity than sentence length". He suggested that the "minimal terminable unit" or "T-unit" should be defined as "one main clause plus whatever subordinate clauses are attached to it or embedded within" (p.190). Further comment about the subordinate clauses made by Hunt (1973) is worthy of note here. On the subject of three kinds of subordinate clauses: noun clauses, movable adverb clauses, and adjective clauses, he states that:

Though the total of all three increases with maturity, not all three increase equally. Noun clauses in general are no index of maturity: the number of them is determined instead by the mode of discourse, the subject matter, all the way from the early grades to maturity. Movable adverb clauses do seem to increase with maturity in the very early grades, but the ceiling is reached early, and after the middle grades the frequency of them tells more about mode of discourse and subject matter than about maturity. But adjective clauses are different. From the earliest grades to the latest the number of them increases steadily, and among skilled adults the adjective clause is still more frequent than it is with students finishing high school (p.184).

O'Donnell, Griffin, and Norris' (1967) results confirm Hunt's finding that in usage, length of T-units increased progressively from grade to grade (p.44). They concluded that:

In both speech and writing there were significant overall increases across the grade spans in the use of the whole classes of transformation-produced nominals and adverbials. The overall increase in use of the whole class of coordinations within T-units was also significant in speech, though not in writing (p.89).

With the advent of transformational generative grammar (Chomsky, 1957), many researchers have employed a new approach for studying language features (other than sentence length) which might affect

the difficulty of written language. The generative-transformational theory is based on two "givens": first, a finite set of phrase-structure rules generates the four basic sentence patterns of English; second, another finite set of rules describes the ways in which the four basic sentences can be transformed into other structures which can, in turn, be combined with other sentences in finite stylistic varieties (Evans, 1972-73, p.273).

This approach to the analysis of English sentence structure permitted complex sentences be converted to simple ones simply by reversing the transforming and combining to de-transforming and un-combining (Coleman, 1964, 1965; Coleman & Blumenfield, 1963; Evans, 1972-73).

Coleman and Blumenfield (1963) tested 100 college students on their comprehension of sentences with nominalizations (derived from verbs) against sentences written without nominalizations but with the use of active-verbs. Reading comprehension was measured by means of cloze tests constructed on both nominalized versions and active-verb versions. They found that students reading the de-transformed sentences inserted more correct nouns, verbs, adjectives, and adverbs on the cloze test blanks than the students reading the nominalized sentences did. In another study, Coleman (1964) used cloze tests to compare 48 college students on their comprehension of prose written in two versions (un-simplified versus simplified by transforming nominalizations, adjectivalizations, and passives to their active-verb transforms). He found in all four experiments that nominalizations, adjectivalizations and passives were less comprehensible than their de-transformed active-verb versions. A year later, Coleman (1965) investigated the comprehensibility of four grammatical transformations (nominalizations, adjectivalizations, passives and embedded sentences). In his first experiment, he examined 10 different categories of nominalizations comparing nominalized sentences to those de-transformed using active-verbs. By asking 60 college students to repeat the sentence immediately after seeing it, Coleman found that for six pairs of transformations, the de-transformed active-verb versions were easier to learn. But there were no significant differences, for the other four pairs. Coleman suggested on the basis of this finding that:

Some new insights into readability may be provided by dividing these nominalizations into ones that are relatively difficult to learn versus those that are not (p.334).

His second experiment dealt with the comparison between actives and passives. Forty psychology students were asked to write down what they had remembered, after seeing on a slide projector, a set of six sentences (three actives and three passives). It was found that actives were better retained than passives for all scoring systems. This finding did not provide any evidence to support the notion suggested by Miller (1962) that all grammatical transformations of a sentence are stored in memory as kernels (active, declarative sentences) with a sort of mental subscript denoting the transformation (Coleman, 1965, p.336). His third experiment was conducted to compare the comprehensibility of adjectivalizations and their grammatical transformations using adjectives. The results revealed that there were no significant differences between adjectivalizations and their simplified versions. Coleman commented on this finding that "It is reasonable to conclude that indiscriminately detransforming any and all adjectivalizations will have little effect in making prose easier to comprehend" (p.339). This seems to confirm Hunt's earlier conclusion about the grammatical complexity of adjective clauses (Hunt, 1973, p.184). In a fourth experiment which compared four different kinds of embedded sentences to non-embedded ones, Coleman found that the embedded sentences cause more difficulty to readers than the non-embedded ones.

Another study, by Evans (1972-73) offered further evidence of the effect of de-transformation on reading comprehension. The study compared two identical groups of twelfth grade students, reading two versions of five prose selections. One version had simplified the following four structures -- nominalization, relative clauses, passive voice verbs and grammatical deletions, maintaining a twelve-word average sentence length. The other version was taken as used in The Davis Reading Test. Both groups were tested by multiple-choice questions from the reading test and by cloze tests. The results showed a significant relationship between achievement on the multiple-choice test and on three of five cloze tests of the simplified version.

Fagan (1971) took a slightly different stance. He investigated the effect of the number and/or types of transformations on the reading comprehension of 440 pupils in grades 4, 5 and 6. He grouped into five categories, 43 transformations derived from 21 passages randomly drawn from the grade four basal reader series, namely, embedding, conjoining, deletion, simple-transformation and position shift. Each

of three stories drawn randomly from the three basal reader series was then written in four different forms. Each form contained 20 transformations. Twelve of these transformations consisted of one of the four major transformation types - embedding, conjoining, deletion and simple, while the remaining eight transformations came from the other three categories. The results revealed that the presence of deletion and embedding transformations tended to make sentences and passages difficult for children to read. Specific transformations causing the most difficulty were reported. They were appositives, ing-nominalizations, genitive pronouns, common elements deletions and negatives. Fagan also found that sentence difficulty was more dependent on the presence and difficulty of transformations than was the difficulty of the passage. He commented that this could be explained in terms of redundancy of language: "Information which an individual may miss within the boundaries of a particular sentence may be acquired within some other sentences of the passage" (Fagan, 1971, p.171).

The effect of shortening compound and complex sentences on the comprehensibility of passages was studied by Coleman (1962). He rewrote each of the three originally difficult passages in two other versions (one containing 6 sentences, and one containing 15), by dividing the compound and complex sentences into shorter ones. The comprehensibility of these passages was measured by the cloze technique. The results indicated that the effect of shortening sentences was small. However, the detailed analysis of the sentences enabled Coleman to make the following predictions:

- (a) It may improve comprehensibility if "clause fragments" such as subordinate clauses are raised to full sentences.
- (b) It may improve comprehensibility to divide sentences joined by conjunctions (but, for, because, etc.) that signal that the 1st clause is qualified by the 2nd one.
- (c) It will not improve comprehensibility to divide a sentence joined by "and" into 2 sentences.
- (d) Shortening clauses may be more effective than merely emphasizing their boundaries by punctuating them as separate sentences (p.131).

The third statement was later supported by the study of Drumm (1974) who found that passages which made use of the conjunction "and" to join short sentences into larger units were significantly easier for the primary children to comprehend than were passages which contained short simple sentences.

Shortening and simplifying written materials was also found to improve their comprehensibility. Schulz Von Thun, Von Berghes, Langer, and Tausch (1976) "improved" 10 summaries of publication from two psychology journals along four dimensions; simplicity, organisation-structure, brevity and additional stimulation. Comprehension and retention were assessed in a free recall and written examination. Results revealed that students at different academic levels secured higher scores on all 10 revised summaries.

Several other studies attempted to pinpoint specific grammatical difficulties contributing to poor reading. Robertson (1968) investigated pupil understanding of 17 connectives from three basal reading series. The Connectives Reading Test of 150 multiple-choice items, a test of mental ability, and a standardized achievement test were administered to a sample of 402 fourth, fifth and sixth graders. Results indicated (i) that understanding of connectives was significantly related to sex, mental age, listening, reading and writing ability, and (ii) increased significantly with an increase in grade level. Six connectives which caused difficulty for 34% or more of the students were: however, thus, although, which, and, yet.

Stoodt (1972) attempted to determine if an understanding of conjunctions was related to reading comprehension. With textual readability held constant, three cloze tests were developed to measure comprehension of conjunctions -- one with a large number of conjunctions, another with half as many conjunctions, and the third with no conjunctions. Three cloze passages, a multiple-choice test of conjunctions, a standardized reading achievement and mental maturity test were administered to a stratified random sample of 95 fourth grade students. A significant relationship between reading comprehension and understanding conjunctions was found for both the multiple-choice and the cloze measures. The most difficult conjunctions were reported. They included when, so, but, or, where, while, how, that, and if.

The studies reviewed above, revealed that "grammatical complexity" has been interpreted in many different ways. Whether determined by "sentence length", "clause length", "sentence structure", "types of transformation", "number of transformation", "types of conjunction", the grammatical complexity of a sentence or of a passage has been demonstrated to affect the comprehension difficulty of a written language.

English Complex Structures

Attempts have been made in several studies to investigate the effects on comprehension of such features (i) position of the embedded clause, (ii) surface cues in the surface structure, (iii) word order within clauses, (iv) clause order, (v) grammatical functions of the identical noun phrases.

English relative clauses

Earlier studies of relative sentences have shown that sentences with multiply self-embedded relative clauses such as in, "The prize that the ring that the jeweller that the man that she liked visited made won was given at the fair", were more difficult to process than sentences with right branching relative clauses as in, "She liked the man that visited the jeweller that made the ring that won the prize that was given at the fair" (Blumenthal, 1966; Chomsky & Miller, 1963; Miller & Isard, 1964; Stolz, 1967). Miller and his co-workers (Chomsky & Miller, 1963; Miller & Isard, 1964), explained that sentences containing self-embedded relative clauses are difficult because such clauses interrupt the clauses in which they are embedded.

Several other studies have demonstrated further that the presence of surface cues in relative sentences has an effect on sentence comprehensibility. The Fodor and Garrett (1967) study involved doubly self-embedded sentences like (i) where relative pronouns were present and (ii) where relative pronouns were deleted.

- | | | |
|------|---|--------------------------------------|
| (i) | The car which the man that the dog
bit drove crashed | (unreduced self-
embedded clause) |
| (ii) | The car the man the dog bit drove
crashed. | (reduced self-embedded
clause) |

In their experiments, subjects heard nine doubly self-embedded sentences, either reduced or unreduced. After hearing the sentences, subjects were to paraphrase them, i.e. to say in their own words what it meant. Each sentence was presented and paraphrased five times in succession. The data were analyzed in terms of paraphrase accuracy and also in terms of response delay. On both response measures, performance was better with the unreduced sentences. That is, the paraphrase were both quicker and more accurate when the sentences were unreduced. Fodor and Garrett

(1967) and Fodor, Garrett, and Bever (1968) explained the role of surface cues in the surface structure. Understanding a sentence requires the recovery of the grammatical relations underlying the sentence. The hearer, it is assumed, in recovering the relations, utilizes cues in the sentence's surface structure as a basis for projecting hypotheses about the underlying grammatical relations. A sentence is easy or difficult to comprehend to the extent to which such surface cues are available, and further to the extent to which the grammatical relations receive a distorted representation in the surface structure.

Foss and Lynch (1969) have reported an experiment which compared (i) reduced with unreduced doubly self-embedded sentences and (ii) doubly self-embedded sentences with right branching sentences as in, "The dog bit the man that drove the car which crashed." Comprehension was measured by response latency on the "phoneme monitor" task. Under this task, subjects had to listen in each sentence for a word beginning with a particular letter and, if they heard one, press a button. Foss and Lynch's results indicated that there were no sentence type differences when the monitor word occurred early. When it occurred late, latency for the right branching sentences was significantly less than for either reduced and unreduced self-embedded sentences. But there was no difference between reduced and unreduced self-embedded sentences. This latter result was inconsistent with those of Fodor and Garrett (1967) who used the paraphrase task as a measure of comprehension.

This conflicting result made Hakes and Cairns (1970) question the validity of the two types of measure of comprehension used in the previous studies. Hakes and Cairns (1970) accordingly used doubly self-embedded sentences, differing only in whether the relative pronouns were present or deleted. They gave them to two groups of subjects who were required to respond to a word beginning with a particular letter in each sentence (a "phoneme monitor" task) and to paraphrase the sentence. The results from both tasks indicated that comprehension was better when the relative pronouns were present than when they were deleted. These results were consistent with Fodor and Garrett's (1967) results for the paraphrase task but were not consistent with Foss and Lynch's (1969) results which used the phoneme monitor task. Hakes and Cairns concluded that the phoneme monitor task reflected comprehension difficulty in a manner consistent with the paraphrase task and that deleting the relative pronouns made comprehending self-embedded sentences more difficult.

Hakes and Foss (1970) investigated the usefulness of relative pronouns as cues to the deep structure underlying self-embedded sentences. At the same time, their study compared the relative sensitivity of two measures of sentence-comprehension difficulty -- paraphrasing and phoneme monitoring. Ninety sentences from the Foss and Lynch experiment (30 of which had right branching relative clauses, 30 of which had reduced self-embedded relative clauses and 30 of which had unreduced self-embedded relative clauses) were presented to students from introductory psychology classes. It was found that the presence of the relative pronouns led to significantly faster phoneme monitoring times and to marginally better paraphrasing. They concluded that relative pronouns were effective cues and that the phoneme monitoring technique was a better index of comprehension difficulty than was the paraphrasing technique.

The role of the relative pronouns in the comprehension of relative sentences was also investigated in child language development research. Brown (1971) in studying children's comprehension of relative sentences examined three syntactic variables. They were (i) embeddedness position of the clause (centre-, right-, and ambiguous embeddedness), (ii) focus of the relative pronoun (subject or object focus), and (iii) the relative pronoun itself (who, who-deletion, which, that). A picture cued comprehension test which incorporated all three variables, was administered to three groups of children three, four and five years of age. Analysis of variance showed that in overall performance three year olds had significantly lower scores than four and five year olds. Embeddedness was non-significant except in the case of an added structural ambiguity. Subject focus was significantly easier to comprehend than object focus.

Studies of comprehension of relative sentences have further examined factors as the appropriateness of subject-verb relations (Hamilton & Deese, 1971), clause order effect (Holmes, 1973) and word order within clauses (Edwards, 1969; Hakes, Evans & Brannon, 1976; Sheldon, 1974). Hamilton and Deese (1971) investigated two determiners of comprehensibility of complex sentences -- the surface form of complex sentences and the appropriateness of the nouns which were subjects of the various clauses in these sentences for their respective verbs. Thirty subjects listened to tape recordings of 288 sentences of two to five clauses in length, and during a 2-second interval between sentences, were asked to label the sentence as comprehensible or incomprehensible and to record the degree of confidence they held in this judgement on a 7-point scale.

All subjects responded to "right-branching", "centre-embedded" and "mixed" sentences. Right-branching sentences ("The congregation complimented the organist that directed the choir that sang new hymns.") were judged to be most comprehensible, and centre-embedded sentences ("The choir that the organist that the congregation complimented directed sang new hymns.") least comprehensible. The mixed type ("The choir that the organist directed that the congregation complimented sang new hymns.") was intermediate in comprehensibility. The comprehensibility of right-branching sentences was scarcely affected by length, though this did affect the centre-embedded and mixed forms. Findings on the ratings of the appropriateness of the subject noun and verb combination however, revealed a low positive but significant correlation with the comprehensibility ratings for all sentences. Hamilton and Deese concluded that "grammatical structure, including both syntax and category rules, was the major determiner of comprehensibility" (p.169).

Holmes (1973) conducted an experiment which compared the perceptual complexity of the three types of complex sentences (adverbials, complements and relatives) in order to see whether processing the main clause first decreased perceptual complexity. According to the proposed "main-clause-first" hypothesis, sentences with an adverbial clause after the main clause were hypothesized to be easier to perceive than sentences with an adverbial clause occurring before the main clause. Sentences in which a relative clause modifies the object of the main verb (right-branching relatives) were hypothesized to be easier than sentences with a relative clause modifying the subject (centre-embedded relatives). Noun-phrase complement sentences in which the subordinate clause is the object (object complements) were hypothesized to be easier than sentences in which the subordinate clause is the subject (subject complements). Forty subjects were presented with 72 sentences of six types of syntactic construction. They were instructed to write out the sequences as accurately as possible and without guessing, after they have seen each sentence in the film. The findings indicated the effect of the clause order where the main clause occurs first for adverbials and noun-phrase complements. The reverse was found for relatives, that is, right-branching relatives were found to be more difficult than centre-embedded relatives. Holmes (1973) discussed the conflicting result in terms of the construction of the sentences which required "naturalness", the effects of guessing and the rapid-serial-visual presentation task used in the study. Holmes concluded:

How the perceptual advantage of centre-embedded over right-branching relatives is to be explained is not clear at present. Several possibilities suggest themselves. For example, the difficulty of right-branching relatives may derive from ambiguity of reference of the relative clause. Alternatively, storage requirements for the preceding input may be greater in the case of right-branching relatives. Such accounts are completely ad hoc, however, and further research is obviously required to discover what the underlying perceptual mechanisms are (p.292).

A research study was conducted by Edwards (1969) who examined 80 high school senior students' comprehension of 16 types of relative sentences. Three syntactic variables across sentence types were investigated -- the relative clause position, independent clause structure and relative clause structure. Comprehension of sentences was measured by having the subjects read each sentence silently, then complete a written paraphrase of the original sentence to show their understanding of it. Analyses of variance indicated that relative clause position, independent clause structure, and relative clause structure all affected comprehension scores. Sentences were easier to understand if the relative clause appeared second, at the end of the independent clause, rather than first. Sentences also were easier if the independent clause was active rather than passive. The effect of the third variable, relative clause structure, could be traced to the difficulty of one type of relative clause, -- where the agent is mentioned first and the verb is passive (e.g. ... that the girl was disliked by).

In an experiment which investigated children's comprehension of four types of sentences with relative clauses, Sheldon (1974) attempted to test three hypotheses about the role of grammatical variables in the acquisition of relative clauses. On the basis of the interruption hypothesis, Sheldon predicted that subject relatives (for example, "The boy who hit the girl saw the man.") would be harder to process than object relatives (for example, "The man saw the boy who hit the girl."), because the former contained an interruption of the main clause by the embedded clause. On the basis of the word order hypothesis, Sheldon predicted that relative clauses in which the subject noun phrase relativized (for example, "... the boy who hit the girl...") would be easier to process than relative clauses in which the object noun phrase relativized (for example, "... the boy who the girl hit ..."). This

was because, according to the standard treatment of relativization, the underlying word order is preserved in the surface structure of the relative clauses in which the subject noun phrase is relativized. The third hypothesis which was proposed by Sheldon (1974), "the Parallel Function Hypothesis", claims that "children will be following a strategy of interpreting the grammatical function of the relative pronoun as being the same as its antecedent". Based on the hypothesis, Sheldon predicted that those sentences in which the shared nominals had the same grammatical function in their respective clauses (for example, "The man saw the boy who the girl hit" would be easier to process than sentences in which the coreferential noun phrases had different grammatical functions (for example, "The man saw the boy who hit the girl."). Thirty-three children with the age ranging from 3.8 - 5.5 were involved in the study. Their comprehension was measured by a toy-manipulation task. A total of 12 sentences were presented in three blocks, each of which contained four sentences. Each child was asked to perform the sentences to verify that he understood the procedure and could act out the sequence of two actions. The results indicated that if the identical noun phrases have the same function in their respective clauses, the sentence is significantly easier to understand. The level of performance on the self-embedded sentences, however, was not significantly different from that on the right-branching sentences. Comprehension of relative clauses in which the subject noun phrase was relativized was not significantly different from those in which the object noun phrase was relativized. On the basis of these results, Sheldon (1974) concluded that "the Parallel Function Hypothesis" is crucial for the explanation of certain facts about the acquisition of relative clauses in English" (p.279).

Another study which questioned whether the interruption hypothesis accounts for the difficulty of self-embedded sentences was conducted by Hakes, Evans and Brannon (1976). Hakes et al. (1976) argued that the self-embedded and right-branching relative sentences that have been used in the previous studies which confirmed the difficulty of self-embedded clauses over the right-branching relative clauses, have differed in the internal structure of the relative clauses used. Hakes et al. (1976) stated:

The relatives used in the self-embedded sentences have been object relatives, ones in which the direct object of the clause has been fronted and relativized. Those used in the right-branching sentences, however, have

been subject relatives, ones in which the subject of the relative clause has been relativized. Given this confounding of a difference in relative clause location with a difference in the internal structure of the relatives, it is entirely possible that the results of all the pertinent experiments could be attributed to the internal structure difference rather than to the difference between self-embedded and right-branching locations (p.284).

Realizing that such factor as the internal structure of the relative clause might account for the difficulty of relative sentences, Hakes et al. (1976) designed two experiments which held the internal structure of the relative clauses constant while varying their location. Experiment 1 compared the comprehension difficulty of self-embedded as in (i) and right-branching object relative clauses as in (ii) on two measures of comprehension: paraphrasing and phoneme monitoring.

- (i) After the final curtain on opening night, the director (that) the repertory company had hired praised the star performer.
- (ii) After the final curtain on opening night, the star performer praised the director (that) the repertory company had hired.

The object relative clause in sentence (i) modifies the subject (self-embedded) of the sentence's main clause, whereas the object relative clause in sentence (ii) modifies the object (right-branching) of the sentence's main clause. Experiment 2 compared the comprehension difficulty of self-embedded as in (iii) and right-branching subject relative clauses as in (iv) on both measures used in Experiment 1.

- (iii) The children (that were) playing in the hayloft startled the farmer's wife when she went to gather the eggs.
- (iv) The farmer's wife startled the children (that were) playing in the hayloft when she went to gather the eggs.

The subject relative clause modifies the subject (iii) or the direct object (iv) of the sentence's main clause. The results indicated that

there was no evidence that sentences containing self-embedded relatives were more difficult to comprehend than ones containing right-branching relatives. They suggested that findings of past research could be accounted for by the fact that object relative clauses were more difficult to comprehend than subject relative clauses, rather than the alternative explanation that self-embedded relatives were more difficult than right-branching relatives.

The studies on comprehension of relative clauses reviewed so far have all involved native speakers of English. The section which follows covers non-native speakers of English.

Perkins and Yorio (1974) attempted to find out (i) to what extent grammatical complexity contributed to difficulty in the comprehension of sentences and (ii) which structures non-native speakers of English found particularly complex. A 50-item reading test was constructed and administered to a group of 38 advanced students enrolled in the intensive courses of the English Language Institute at the University of Michigan. The same test was also administered to 20 freshmen and sophomores for control purposes. The grammatical structures under investigation were (i) possessive vs multiple possessive configurations, (ii) word morphology, (iii) different types of relative clause constructions, (iv) passive constructions, (v) sentence nominalizations, (vi) ambiguous structures: gerundive vs participial constructions, (vii) different cases of presuppositions and entailments. The analysis revealed that there was no correlation between student errors and the length of the sentences or words. Passive constructions and sentences containing presuppositions and entailments however appeared to constitute real obstacles for comprehension even for students with a high level of proficiency. In the case of the relative clauses, a very small number of errors was found. This seemed to indicate that for the advanced group in the study, relative clauses did not cause much difficulty. Perkins and Yorio (1974) pointed out that the number of errors found on each type of relative sentences however seemed to indicate the role of the grammatical complexity on sentence difficulty. They reported:

The simplest case of relative clause that we had was:

"The mailman carried the bag which contained the letters."

No errors were made. The medium difficulty sentence with two relative clauses was: "The man who won the contest in 1971 married the girl who won the contest

in 1972." With this second sentence there was one error. The most complex sentence of the relative lot was: "The John Smith who introduced the speaker who received the award is not the same as John Smith who received the first award ever given two years ago." This time the number of errors was four (p.4).

Although Perkins and Yorio (1974) did not set out to investigate particularly self-embedded relative clauses versus right-branching relative clauses, the data seemed to reveal that right-branching relative sentences were easier for the subjects of their study.

The effect of syntax on the comprehension of written English was also discovered in a pilot study conducted by Nilagupta (1977). The English Screening Test consisting of three subtests - vocabulary, structure comprehension and reading comprehension, was administered to 1,278 Thai graduates. Only the scores from the Structure Comprehension Subtest and from the Reading Comprehension Subtest were analyzed. The data were selected by taking every third answer sheet from a total of 1,278. A positive relationship was found to exist between the scores on structure comprehension and reading comprehension. The correlation obtained was $r = .54$. Further analyses of student performances on individual test items revealed that negative words, the passive voice, embedding, deletion and nominalization seemed to cause difficulty for these Thai students. On the basis of the results, Nilagupta (1977) further commented that there might be different levels of difficulty within the same type of structure. As an illustration, she pointed out that not all embedded relative clauses and appositive phrases cause difficulty in comprehension (p. 592).

The difficulty of English relative clauses has also been examined in second language learning research (Scott & Tucker, 1974; Schachter, 1974).

Scott and Tucker (1974), applying an error-analysis approach, examined types and frequency of errors from both the speaking and writing of Arabic students enrolled in an Intensive English Course at the American University of Beirut. Verbs, prepositions and articles were reported as "the areas where the students most often deviated from standard English. Relative clauses were also a frequent source of error" (p.75). The types of errors frequently made in relative clauses included omission of the relative pronoun, repetition of the object, incorrect word order

and subject-verb agreement.

Another error-analysis study was conducted by Schachter (1974) who attempted to discover the difficulties that different groups of foreign students (Persian, Arabic, Chinese, Japanese) have with the acquisition of English relative clauses. Based on the number of errors made by the four groups, Schachter (1974) reported that "the Persian and Arab learners have far more difficulty producing relative clauses than do the Chinese and Japanese learners" (p.209-210). However, Schachter was cautious to conclude on the sole basis of error-analysis data that because Chinese and Japanese students made few relative clause errors in the data, the relative clause was quite a minor problem for these groups. Schachter pointed out that such a conclusion might be biased for it did not account for the avoidance process. Schachter thus examined further the total number of relative clauses produced by the four groups. The results revealed the difference in the total number of relative clauses produced by the Persian (174) and Arab (154) students on the one hand, and the Chinese (76) and Japanese (63) students on the other. The Persian and Arab students produced more relative clauses because, Schachter explained, they already have postnominal relative clauses in their native languages. Chinese and Japanese students, on the other hand, have prenominal relative clauses in their native languages and must learn to switch relative clauses to a postnominal position in the process of learning English (p.210). Schachter pointed out that:

... they (Chinese and Japanese) produce fewer relative clauses in English because they are trying to avoid them, and that they only produce them in English when they are relatively sure that they are correct, which would also account for the extremely small number of errors they make ... (p.210).

To conclude, several native speaker studies of comprehension of English relative sentences have demonstrated that multiply self-embedded relative sentences are more difficult to process than right-branching relative sentences. Other studies (Fodor & Garrett, 1967; Hakes & Cairns, 1970; Hakes & Foss, 1970) found additionally that the comprehension of sentences with multiply self-embedded relative clauses is facilitated by the presence of relative pronouns. Recent work (Sheldon, 1974; Hakes et al., 1976) attempted to validate the interruption hypothesis which claims that self-embedded relatives are harder to process than

the right-branching relatives because the former contain an interruption of the main clause by the embedded clause. Sheldon's (1974) findings seem to indicate that relative sentences are more difficult when the identical noun phrases have different grammatical functions. Again Hakes et al.'s (1976) results tend to reveal that the internal structure of the relative clause might have an effect on comprehension difficulty of English relative sentences. Although certain factor which accounts for the difficulty of English relative sentences is not definitely established, general findings from the previous studies seem to indicate that such factors as the position of the embedded clause, the surface cues in the surface structure, clause order, word order within clauses, may partly have an effect on sentence difficulty.

Non-native speaker research on the comprehension of English relative structures seems to indicate that this type of complex English structure is difficult to learn. However, very few studies were conducted to examine whether various relative structures are equally difficult for second or foreign language learners. Moreover, studies which investigate why certain type of English relative sentences are more difficult than others, have not been conducted.

English complement structures

Another type of complex English structure, complement structure, as in sentences (i) to (iv) below (taken from Chomsky, 1969) has also received considerable attention from linguists, psycholinguists, second language specialists and reading researchers.

- (i) Don allowed Fred to stay.
- (ii) Don promised Fred to stay.
- (iii) John told Bill what to do.
- (iv) John asked Bill what to do.

Such sentences as in (ii) and (iv) are generally regarded as being difficult to comprehend. Several studies have been devoted to demonstrating that they are more difficult to comprehend than sentences (i) and (iii).

In a study of the acquisition of syntax in children between the ages of five and ten, Chomsky (1969) investigated the developmental pattern of a set of complex linguistic structures which appeared to be liable for late acquisition. Among the structures investigated,

complement clauses as in sentences (i) to (iv) above, were also included in her study (Chomsky, 1969). According to Chomsky (1969), the complement clauses in sentences (i) and (iii) conform to the syntactic rule known as the "Minimal Distance Principle" (MDP), that is, the implicit subject of the complement verb is the NP most closely preceding it (p.10). For example, in sentence (i) Fred is the subject of the complement verb stay. Similarly, in sentence (iii), Bill is the subject of the complement verb do. On the other hand, the complement clauses in sentences (ii) and (iv) violate the MDP principle. In sentence (ii), for example, the subject of the complement verb is not the immediately preceding noun but rather is the subject of the main verb: Don is the subject of promised and of the complement verb do. In sentence (iv), John is the subject of the main verb asked and of the complement verb do. The results of this study indicated that complement clauses which violated MDP as in (ii) and (iv) were more difficult to comprehend than those which conformed to the MDP principle.

Chomsky's work (1969) has been replicated and extended by several researchers (Cooper, Olshtain, Tucker & Waterbury, 1979; Cromer, 1970; d'Anglejan & Tucker, 1975; Kelleher, 1973; Kramer, Koff & Luria, 1972). Results generally confirm Chomsky's findings.

Unlike other previous studies where comprehension was demonstrated orally in individual interviews, Richek (1976) investigated 101-third, -fourth, -fifth graders' comprehension of complements where comprehension was demonstrated in a reading context in which subjects were free to reinspect the linguistic stimuli. Two classifications of four types of syntactic structures: those of subordinate clauses which conform to a Minimal Distance Principle as in sentences (i) and (ii) below and those which violate it, as in sentences (iii) and (iv) below, were presented to the subjects.

- (i) John convinced Bill to do the homework.
- (ii) John managed to take the ball from Bill.
- (iii) John amazed Bill by winning the prize.
- (iv) John visited Bill in order to give the gift.

The findings confirmed findings that structures violating the MDP have not been completely mastered by the early school years. When the two structures that conformed to the MDP were examined, Richek reported:

... no differences are observed between a structure in which the subordinated clause is preceded by two nouns and a subordinated clause which is preceded by only one

noun see Sentences (i) and (ii)). This suggests that sentences in which the closest of two preceding nouns is to be chosen are no more difficult than sentences in which only one noun precedes the subordinate clause (p.804).

For the structure types that violate the MDP, Richek found that:

.... no differences are observed between an adverbial clause and a complement structure (see Sentences (iii) and (iv))(p.804).

d'Anglejan and Tucker (1975) investigated the acquisition of complex English structures by adult non-native speakers of English. Five sets of complex English structures described by Chomsky (1969) were adapted. Among these structures were infinitival complements as in sentences (i) to (iv) below.

- (i) Don allowed Fred to stay.
- (ii) Don promised Fred to stay.
- (iii) The girl tells the boy what to paint.
- (iv) The girl asks the boy what to paint.

To test comprehension of complement structures as in (i) and (ii), two experimental groups of 20 French Canadians at beginner and advanced levels of English proficiency, were asked to answer a simple question to each sentence read aloud by the experimenter. Comprehension of complement structures as (iii) and (iv) was measured by asking the subjects to choose a picture which was a correct interpretation of the question asked by the experimenter. The results on comprehension of complement structures as in (i) and (ii) were reported:

The pattern of errors for the BEG (Beginner) group indicates that they did not distinguish between target and control sentences. They still have not mastered the minimal distance principle and they are generally responding to sentences in an erratic way (p.288).

Similar findings were achieved for the comprehension of complement structures as in (iii) and (iv):

The performance of the ADV (advanced) and NS (native speakers of English) groups was essentially similar. Both appeared to apply the minimal distance principle but recognized that ask and tell questions, despite their similarity in surface structure, derive from two different deep structures involving a different set of underlying relationships.

The BEG group performed similarly to the two other groups when dealing with tell sentences which follow the broad syntactic rule. However, they differed from the other groups in their handling of the ask sentences which violated the minimal distance principle (p.290).

An attempt to extend the work of d'Anglejan and Tucker (1975) was made by Cooper, Olshtain, Tucker and Waterbury (1979). Their investigation examined the acquisition by Egyptian and Israeli adult learners at different levels of proficiency, of five sets of complex English structures. The same test materials devised by d'Anglejan and Tucker (1975) were used. Similarly to d'Anglejan and Tucker, Cooper et al. (1979) found that, for the less advanced students, the error rates for sentences which violated the MDP principle were higher than for the sentences which conformed to the MDP.

"Surface cues" which had been found to have an effect on the comprehensibility of English relative sentences, were investigated by Hakes (1972) in sentences with complement clauses. Following Fodor and Garrett's (1967) theory of sentence comprehension (which holds that deletion of an optional cue to sentence structure increases comprehension difficulty), Hakes (1972) demonstrated further that sentences which contained that-complement construction where the complementizer was present (as in (i) below) were easier to comprehend than that-complement construction where the complementizer was absent (as in (ii) below).

- (i) The blind student felt that the material in the art course would be too difficult for him to understand.
- (ii) The blind student felt the material in the art course would be too difficult for him to understand.

In Hake's study (1972), 40 students from the freshman-level introductory psychology course served as subjects in two experiments. Comprehension in both experiments was measured by both paraphrasing and phoneme monitoring tasks. Hakes (1972) concluded that:

The phoneme monitoring results for the two experiments are consistent in indicating that when an optional cue to a sentence's underlying grammatical relations is deleted, the difficulty of comprehending is increased.

.....

The paraphrasing data for the two experiments, taken together, suggest the same conclusion as the phoneme monitoring data, though not nearly so strongly ... (pp.283-284).

Conclusion

General findings from research on the role of language and its relation to reading comprehension seem to indicate that there exists a relationship between knowledge of English grammar and reading comprehension for both native and non-native speakers of English. These studies, however, have tended to investigate general English reading materials and to involve generally students whose interests are not in science. More investigation is needed to see whether the relationship between comprehension of English grammatical structures and reading comprehension of scientific English reading materials exists when non-native English science students are the focus.

Again several attempts have been made to demonstrate the effect of language structure on reading comprehension both at the paragraph level and at the sentence level. Such factors as sentence length, clause length, sentence structure, types of transformation, number of transformation, types of conjunction, have been shown to have an effect on the difficulty of reading passages for native English speakers. Very few researchers have shown an interest in examining language variables in the readability of reading materials for non-native speakers of English. Recent work has emphasized surface complex structure which might have an effect on sentence comprehension. Again this has been investigated extensively in the first language learning area. General findings seem to indicate that such factors as surface cue, word order within clauses, clause order, partly have an effect on comprehension of complex English structures.

Attempts have not been made to undertake similar work on non-native speakers of English.

"Cloze" Technique

The "cloze procedure"^{is} to be used in the present study to measure the students' degree of understanding of selected scientific English passages. Most previous research on cloze procedure as a measuring instrument has been carried out with English language materials and with native speakers of English. Findings generally show that the technique is a reliable and valid measure of both readability and reading comprehension for native speakers. However, very few studies have applied the procedure to technical prose materials and used it with non-native speakers. Because the present study is to attempt to establish the validity of the procedure as a measure of reading comprehension for non-native English speakers, it is necessary to provide here a full background on the procedure. This part of the review thus includes a consideration of the definition of the procedure, followed by a review of validity studies of cloze as a measure of reading comprehension for both native and non-native speakers of English. The cloze test reliability, its methodological considerations and its scoring procedures will also be described.

Definition

The term "cloze procedure" first appeared in the professional literature in 1953 when it was used by Taylor for a measure of readability. He adapted the word "cloze" from the Gestalt psychology concept of closure which means filling in the parts in an incomplete pattern in order to arrive at a meaning. Taylor's reasoning was that if a person, in order to understand the message of a printed passage when words were removed, could replace these words exactly, he was undertaking a form of closure. The test procedure itself entails first the selection of a passage appropriate for the purpose and second the deletion of words from the passage by an objectively specifiable process. The deletion process generally requires that either every thn word or words of a particular type (lexical, structural) are deleted. The words removed are then replaced by blanks of uniform length. The subjects are required to try to complete the blanks by guessing the word which has been deleted. The forms may be scored

by counting as correct only those insertions which match exactly the words that have been deleted or by accepting in addition to exact replacements, synonyms of words deleted.

Since Taylor (1953) introduced the cloze procedure to assess the readability of written passages, several researchers have further investigated the appropriateness of the procedure for this purpose and generally concluded it to be a valid measurement of readability -- that is, (i) of English materials for native speakers (Beard, 1967; Bormuth, 1963, 1967; Gallant, 1964, 1965; Jefferson, 1969; Knight, 1966), (ii) of English materials for non-native English speakers (Anderson, 1972) and (iii) of materials in other languages, e.g. Korean (Taylor, 1954), Japanese (Shiba, 1957), Thai (Rufener, 1972), Malay (Anderson, 1976) and Mandarin (Anderson, 1976). In addition to being used as a measure of readability, the procedure has also been claimed to be a measure of reading comprehension. Taylor (1956) who suggested that the method could be used for measuring comprehension, reasoned that "if the statement that a passage is 'readable' means that it is 'understandable', then the scores that measure readability should measure comprehension too"(p.44). He thus assumed that readability and comprehensibility are synonymous terms. Studies of cloze procedure have further attempted to provide evidence for the claim that the cloze test is a valid measure of reading comprehension for both native and non-native speakers.

Validity: Cloze as a Measure of Reading Comprehension for Native Speakers

Rankin (1959), in his review on the cloze procedure, discussed the validity of cloze tests as measures of reading comprehension from the standpoint of general reading comprehension and specific reading comprehension. The validity of cloze tests as measures of general reading comprehension tend to be tested by correlating cloze scores with standardized tests of reading. Validity of specific reading comprehension tend to be tested by correlating cloze tests with comprehension tests made over the same passages.

Most of the cloze validity studies have shown its concurrent validity by correlating cloze test scores with scores on other reading tests. Table 1 which has been reproduced from Anderson (1976) shows the correlation coefficients between cloze tests and standardized tests of reading achievement at the primary, secondary and tertiary levels.

Table 1

Validity of Cloze Tests as Measures of General Reading Comprehension

Study	Test	r
Primary		
Brual (1962)	Schonell R.4	0.67
	Watts Sentence Reading	0.72
Ruddell (1963, 1965a)	Stanford Achievement Paragraph Meaning	0.61-0.74
Gallant (1964, 1965)	Metropolitan Reading Achievement	0.71-0.79
McLeod (1965)	Schonell R.4	0.67-0.76
	Watts Sentence Reading	0.75-0.82
Anderson (1965)	Gap Reading Comprehension	0.75
Ruddell (1965b)	Stanford Achievement	0.72 & 0.78
	Paragraph Meaning	
Ransom (1965, 1968)	Informal Reading Inventory	
	Independent Level	0.50
	Instructional Level	0.84
	Frustration Level	0.81
Secondary		
Jenkinson (1957)	Cooperative Reading C-2	
	Vocabulary	0.78
	Level of Comprehension	0.73
Tertiary		
Rankin (1957)	Diagnostic Reading Survey	
	Story Comprehension	0.29
	Vocabulary	0.68
Fletcher (1959)	Paragraph Comprehension	0.60
	Cooperative Reading C-2	
	Vocabulary	0.63
	Level of Comprehension	0.55
	Speed of Comprehension	0.57
Dvorak-Van Wagenen		
	Rate of Comprehension	0.59
Hafner (1964)	Michigan Vocabulary Profile	0.56
Weaver & Kingston (1963)	Davis Reading	0.25 & 0.51
Greene (1964, 1965)	Diagnostic Reading Survey	0.51

The results in general indicate moderate to high correlations with the occasional one quite high ($r = .84$, $r = .81$ Ransom) and one quite low ($r = .25$ Weaver & Kingston). Recently, more validity studies have been reported. For example, Prange (1974) investigated the relationships between two forms of the cloze test and standardized measures of critical reading, general reading and intelligence administered to sixth grade students. She reported:

The correlations among all measures were moderately high and positive, .48 to .88. Cloze Test I (structural deletion pattern) and Cloze Test II (lexical deletion pattern) were positively .48 to .64 and significantly related to tests of critical reading performance. Cloze Test I and II correlated .65 and .72 with word meaning and .70 and .74 respectively with paragraph meaning. Similar correlations were found between Cloze Test I and the Otis-Lennon, .69, and Cloze Test II and the Otis-Lennon, .73 (Prange, 1974, p.6459).

Prange (1974) concluded that "the data of this study suggest that cloze tests tap many of the same processes or behaviors assessed by standardized group reading comprehension and written intelligence tests" (p.6459). Another study by Salup (1975) compared the cloze scores with the scores from the Cooperative English Test, Comprehension 1 C. Both tests were administered twice, first to a group of 559 undergraduate students in the Fall of 1971 and second to a group of 217 incoming students in the Fall of 1972. The correlations obtained were .36 and .67 respectively.

Three studies reported evidence on the "construct validity" of cloze tests. Weaver and Kingston (1963) submitted to factor analysis a battery of 18 cognitive tests which included eight cloze tests and a standardized test of reading comprehension. They found three factors to be predominant. These were, "verbal comprehension", "redundancy utilization" and "rote memory flexible retrieval". The cloze tests related most closely to "redundancy utilization" and only moderately to "verbal comprehension". Such correlations had not been achieved in previous research investigations since most of the literature on the cloze has emphasized a close relationship between cloze tests and tests of verbal abilities. Notably, Bormuth (1969) made several critical comments on the Weaver and Kingston findings on (i) the sample of college students, "a highly select group in which

the ability distribution was undoubtedly severely truncated", and (ii) instruments used "a wide assortment of standardized tests, the content of which had little relationship to the cloze test passages" (p.364). To study the "construct validity" of the cloze procedure, Greene (1964) prepared a test to measure two factors (words and relationships between words) which he assumed accounted for most of the variance in comprehension test results. Significant correlations ranging from .49 to .59 were found between the cloze tests and the criterion tests. However, like Weaver and Kingston (1963), Greene observed that a considerable amount of the variance was not accounted for by the cloze scores and concluded that "the cloze procedure is more complex than was thought". Another study recently tried to establish the "construct validity" of the cloze test. Horton (1974-75) submitted to factor analysis a battery of 15 cognitive tests which included two cloze tests, a paragraph reading test, and 12 tests designed to measure Structure-of-Intellect abilities hypothesized to be related to cloze and paragraph reading. Horton found that the two cloze tests had significant factor loadings on the Evaluation of Semantic Relations factor only, while the paragraph reading test had significant loadings on the Evaluation of Semantic Relations factor and the Evaluation of Semantic Implications factor.

Research studies on the validity of cloze tests as measures of specific reading comprehension showed general agreement in their findings at all levels. In a study with Air Force Trainees as subjects, Taylor (1957) reported a correlation of .70 between a pre-cloze test followed immediately by a comprehension test and a correlation of .80 between a comprehension test followed by a post-cloze test. At the high school level, Jenkinson (1957) found a correlation of .82 between a pre-cloze and a comprehension test. At the elementary level, Bormuth (1967) used fourth and fifth graders as subjects and found a correlation of .95 between nine cloze tests and nine multiple-choice comprehension tests. A similar study was conducted by Rankin and Culhane (1969). They used fifth grade subjects and five passages ranging from fifth to eighth grade in readability level as measured by the Fry Readability Formula. They achieved correlation coefficients between the cloze and multiple-choice tests ranging from .54 to .77, with an average of .68. At the college level, Entin and Klare (1978) compared seven multiple-choice comprehension tests with two forms of seven cloze tests, standard blank and dash blank (dashed underlines replace letters in the deleted word). The correlation coefficients

between the multiple-choice comprehension tests and the cloze tests on the standard blank and on the dash blank were .57 and .61 respectively.

Validity: Cloze as a Measure of Reading Comprehension for
Non-native Speakers of English

The cloze procedure has not only been used to assess reading comprehension of native speakers but also to assess overall language proficiency in English as a Second or a Foreign Language (Aitken, 1977; Alderson, 1979; Darnell, 1968; Hinojotis, 1977; Hisama, 1977; Irvine, Atai & Oller, 1974; Oller, 1972; Oller & Conrad, 1971; Stubbs & Tucker, 1974). The procedure has also attracted interest in its use as a measure of reading comprehension. Although not many such validity studies have been undertaken, those that have been, confirm the cloze test as a valid measure of reading comprehension (Anderson, 1976; Crawford, 1971; Friedman, 1964; Ibe, 1975; Johnson, 1975). For example, Friedman (1964) demonstrated the validity of cloze as a measure of general reading comprehension by correlating cloze scores on 20 selections from McCall-Crabbs Standard Test Lessons in Reading with the Metropolitan Achievement Test. Correlations with vocabulary ranged from .63 to .85 and from .71 to .87 with total reading score. She concluded that cloze procedure was a valid measure of comprehension for foreign students. In testing the specific reading comprehension validity, Friedman correlated cloze scores with scores from the multiple-choice test and found the correlations ranged only from .24 to .43. Friedman attributed these low correlations to special characteristics of the students involved. However the tests she used were very short. Each passage contained only eight to twelve items and this had the effect of reducing the test variance. Anderson (1976), in the second of his series of 10 experiments on cloze procedure, provided evidence for the validity of cloze tests as measures of reading comprehension. He reported correlations between standard- and exact-length (blanks of the same length as the deleted word) versions of cloze tests and a standardized measure of reading comprehension (Watts Sentence Reading Test I) of $r = .61$ and $r = .75$ respectively. His fourth experiment investigated more fully the validity of cloze tests as measures of reading comprehension. A random sample of 150 pupils in Standards 4, 5 and 6 of one primary school in Papua New Guinea were involved in that particular study. Three tests were administered to the subjects: the Cloze Reading Comprehension Test, the Watts Sentence Reading Test I (a standardized measure of reading comprehension) and

a traditional-type Comprehension Test made over the same test passages as in the Cloze Reading Comprehension Test. The findings suggested that the Cloze Test was a reliable and valid measure of both general and specific reading comprehension:

To obtain a concurrent validity estimate of general reading comprehension, total score on the Cloze Reading Comprehension Test was correlated with Watts score. The obtained correlation was 0.78. Similarly, an estimate of concurrent validity of specific reading comprehension was obtained by correlating total score on the Cloze Reading Comprehension Test with total Comprehension score. The correlation was 0.85 (Anderson, 1976, p.87).

Most importantly, when Anderson subjected to factor analysis a battery of six comprehension subtests, three subtests of the Cloze Reading Comprehension Test, and a standardized test of reading comprehension (Watts Sentence Reading Test I), he found that only one factor emerged and this factor accounted for 65 percent of the variance. Anderson concluded that the Cloze Reading Comprehension Test, then, may legitimately be called a reading comprehension test.

While Anderson's study dealt with the subjects at the elementary level, Ibe (1975) investigated the cloze procedure with a group of Southeast Asian teachers of English from nine different countries in Southeast Asia. Ibe (1975) correlated the subjects' scores on the six cloze tests with scores on a 40-item vocabulary test and scores on a 20-item reading comprehension of the standardized English Proficiency test - the Michigan Language Proficiency Test (MLPT). The correlations were found to be high and highly significant. They ranged from .62 to .76. She concluded that "Cloze tests are as valid as multiple-choice tests for assessing reading comprehension" (Ibe, 1975, p.32).

Cloze Test Reliability

Several studies of cloze procedure with native English speakers (Bormuth, 1969; Cranney, 1972-73; Panackal & Heft, 1978; Taylor, 1957) and foreign students learning English (Anderson, 1976; Anderson & Hunt, 1972; Darnell, 1968; Ibe, 1975; Oller, 1972; Oller, Bowen, Dien, & Mason, 1972; Oller & Inal, 1971) have shown the high reliability of the cloze test. Taylor (1957) using Armed Forces Personnel as subjects and employing the "any", "easy" and "hard" cloze forms, found that the

test-retest reliability coefficients for these forms were respectively .88, .80 and .84. In a study using grade four, five and six pupils, Bormuth (1969) computed the reliability of the cloze procedure by the split-half method. Cloze tests were made over nine passages covering a variety of subject matter. Reliability coefficients, when calculated for each of the nine passages ranged from .84 to .88. Ibe (1975) used the split-half or odd-even procedure to obtain reliability coefficients for two probabilistic or random deletion cloze tests and two judgemental deletion cloze tests. The coefficients were .93 and .96 for the former and .94 and .94 for the latter. Ibe concluded:

On the basis of the coefficients obtained it can be said that cloze tests tend to be more reliable because of the larger number of items that can be used to generate a score. The reliability coefficients were not due mainly to the number of items, however. The two judgemental cloze tests had as high reliabilities as the probabilistic cloze tests although the former had only 30 items each while the latter had 43 (Ibe, 1975, p.29).

In a study using grade four, five and six foreign pupils learning English in Papua New Guinea, Anderson and Hunt (1972) found that the cloze test reliability coefficient achieved by coefficient alpha was .89. Anderson (1976) in his first experiment of a series of 10 explored three scoring methods with the same cloze test when it was applied to second language learners. The reliabilities of the scoring methods were calculated using coefficient alpha. Coefficients of .92, .92 and .93 were obtained for the Verbatim, Synonym and Alternate response scores respectively. The same reliability estimate was used in the fourth experiment when he investigated the cloze procedure as a technique for assessing comprehension ability of second language learners in the Pacific Region. The reliability coefficient of the Cloze Reading Comprehension Test was .95. A study by Cranney (1972-1973) using university students, employed the multiple-choice cloze test and the free-response cloze test. The Kuder-Richardson 20 reliability coefficients for these tests were .93 and .86 respectively. When the less effective items from both original forms were eliminated by the use of item-analysis techniques, the reliability coefficients for the multiple-choice cloze form and the free-response cloze form were .83 and .88 respectively. Oller (1972) reported K-R 20 reliability

coefficients of three cloze tests scored by the exact-word scoring method. They ranged from .80 to .92. When the contextually acceptable word scoring method was applied, the reliability coefficients ranged from .90 to .95.

Methodological Considerations

To construct the cloze test, many considerations need to be taken into account, for example the appropriate length of cloze passages, the type of deletions to be made, the rate of deletions and the total number of deletions.

When Taylor (1953) introduced the cloze procedure, he (i) used a completely mechanical method for choosing the words to be deleted and (ii) called for exact replacement of the original word. Comparing random deletion and the every n^{th} deletion procedure, he found that every n^{th} deletion was easier to use. On the other hand, Greene (1965) compared a modified cloze procedure (rational deletion) to the every n^{th} procedure. He found the modified cloze produced a test better in reliability and item performance but not better in validity. He suggested that increased reliability might be sufficient cause to consider using rational deletions in some circumstances. A more controlled study on the frequency of word deletions was undertaken by MacGinitie (1961) who compared the effect of deleting every third, sixth, twelfth and twenty-fourth word. He found that words were equally restorable under sixth, twelfth and twenty-fourth deletion systems but when every third word was omitted, restoration was more difficult. He concluded that context more than about five words distant exercised relatively little constraint. Most researchers accepted MacGinitie's conclusion and used an every fifth deletion rate (Bormuth, 1963, 1967, 1968a, 1969; Cohen, 1975; Hater & Kane, 1975; Panackal & Heft, 1978; Rankin & Culhane, 1969). However, the result cannot be generalized to cover all reading materials and for all ability groups. Other researchers such as Cranney (1972-73) used every tenth word on technical prose materials and with university students.

While most of the studies reviewed so far employed the fifth word deletion, they all dealt with native English speakers. The research on cloze procedure with non-native speakers, however, has shown that a variety of word deletion frequencies has been employed. For example, Stubbs and Tucker (1974) employed fifth word deletion. Oller et al. (1972) and Ibe (1975) employed sixth word deletion. Oller and Conrad (1971),

Oller (1972), Irvine, Atai and Oller (1974) employed seventh word deletion while Anderson (1972) and Porter (1978) used eighth word deletion. Anderson (1976) investigated systematically the frequency of word deletions when cloze procedures were applied to non-native English speakers. In the third experiment of his series of 10 experiments, he compared the effect of deleting every second, fourth, eighth, sixteenth and thirty-second word.

There was a significant difference between every second and every fourth deletion. The difference between every fourth and every eighth deletion was not significant. Nor were the differences between eighth and sixteenth and thirty-second deletions significant. Of the differences between every fourth deletion and the three less frequent deletion systems, only the difference between every fourth and every thirty-second was significant ... The data indicated that cloze units separated by at least seven words of context (every eighth deletion) were statistically independent of each other while cloze units separated by three words of context (every fourth deletion) were not completely independent (Anderson, 1976, p.66).

He concluded that "for passages of similar difficulty to those used in the study and for subjects in the same range of ability, the common practice of deleting every fifth word in cloze test construction is legitimate. That is, resulting cloze units are statistically independent of each other" (Anderson, 1976, p.67). Ibe (1975), on the other hand, investigated the issue with a group of Southeast Asian teachers of English by comparing a judgemental cloze procedure (selected word deletion), to the every sixth word procedure. She concluded on the basis of her experimental findings that:

If the reading passage is easy, judgemental deletion produces essentially the same ordering of scores as probabilistic deletion (every n^{th} deletion). The two sets of scores are very highly and positively correlated. If the passage is difficult, the correlation between probabilistic and judgemental cloze scores is only moderately high (Ibe, 1975, p.32).

Both questions, whether the rational deletion is preferable to the every n^{th} deletion and how many deletions are appropriate, are still

not fully answered, given different kinds of reading materials and different ability groups of non-native English speakers.

In considering what number of deletions to make and how long to make a test, such factors as time, fatigue and the degree of test reliability must be taken into account. According to Taylor (1956) 50 item test provides a sufficient sample for a stable score with chances for easy and hard words to cancel each other out. Bormuth (1964) using 20 passages which ranged in Dale-Chall Readability from about the 4.0 to 8.0 grade levels of difficulty, investigated different test lengths with tests of five items to tests of 50 items. He also investigated five different cloze forms that were made from the same passage. He reported that "the means on different cloze test forms that are made from the same passage differ significantly for tests of 50 items or less. There were significant differences among over half of the 20 sets of test forms used in this study" (Bormuth, 1964, p.306). He concluded that "the differences in difficulty among test forms made from the same passage tend to diminish as more items are included in the test forms" (Bormuth, 1964, p.306).

Scoring Procedure

The scoring method most frequently used with native speakers is to count as correct only exact replacements of deleted words. The results of the research related to scoring are summarized by Oller (1972), who states:

Previous research has shown repeatedly that the best and most convenient method for scoring when native speakers are tested is simply to count the number of exact-words restored to the context (Taylor, 1953; Rankin, 1957; Ruddell, 1963; Bormuth, 1965). Although native speakers tend to get higher mean scores when acceptable substitutes are counted as correct, the increase in total test variance is so slight that the extra effort involved is scarcely worthwhile (Oller, 1972, p.151).

With non-native speakers, previous researchers on cloze tests have preferred scoring systems that give credit for contextually acceptable responses. Darnell (1968) scored responses on given items on the basis of native speaker responses for those same items. Bowen (1969) used a system of scoring which allowed credit for varying degrees of

correctness which were subjectively determined. Oller and Inal (1971) counted any contextually acceptable response as correct.

Two research studies systematically investigated the scoring procedure when non-native English speakers were tested. Oller (1972) used five different scoring methods to score each of the three passages that had different difficulty levels (as measured by the Dale-Chall Readability Formulas). He concluded that:

The best of the five scoring methods investigated here is M2, i.e. the one that counts any contextually acceptable response as correct ... Moreover, the data show that the acceptable-word scoring method is superior in terms of item discrimination and validating correlations regardless of the level-of-difficulty of the test (Oller, 1972, p.157).

Oller's findings were contradicted by Anderson's (1972). Anderson employed four scoring methods on three passages of different readability levels and found that all four scoring methods ranked the passages and the subjects in the same way. Anderson concluded that "the simplest scoring procedure of crediting only exact replacements was both reliable and efficient" (p.72).

As the issue on cloze scoring procedure is a controversial one, recent research studies with non-native speakers have attempted to investigate further. Stubbs and Tucker (1974) were interested in the relationship which existed between scoring the tests for exact replacement and for contextually appropriate responses. They found that with a group of 206 university students in ESL, cloze tests scored both ways correlated very highly with each other ($r = .97, p < .01$). They suggest that the exact word replacement method is as valid as the other method. This result was supported in a study carried out by Irvine, Atai and Oller (1974). It was concerned to check the inter-correlation of cloze and dictation with each other and with the Test of English as a Foreign Language (TOEFL) when the sample comprised 159 non-native speakers of English in Iran. The authors scored the cloze test by both the exact word and the contextually acceptable word methods and obtained a correlation of .94 between the two methods. Another study was carried out by Hinofotis (1977) who investigated the concurrent validity of cloze testing as a measure of overall proficiency in English as a Second Language. Cloze-exact and cloze-acceptable

word scoring methods were correlated with the Test of English as a Foreign Language (TOEFL). The correlations obtained were $r = .71$ and $r = .79$ respectively. When correlated with the CESL Placement Test, the correlations obtained were $r = .80$ and $r = .84$ respectively. Results obtained by the two different scoring methods were then compared. Hinofotis reported that the data did not indicate clearly which scoring method was preferable. In the same vein, Porter (1978) was interested in checking the claim made by Oller (1972) that significantly superior differentiation of ESL speakers is obtained when any contextually acceptable word is counted as correct. He found with a group of 39 Polish students learning English as a foreign language, that "the assertion that acceptable word scoring gives better differentiation with ESL students was found to be generally true of discrimination between individual subjects, but not true of discrimination between year-groups in the population studied" (Porter, 1978, p.340).

Conclusion

Cloze technique, a word deletion process whereby words are removed from a printed passage and the student's task becomes to predict or identify the word which was removed and replace it, has been used to assess reading comprehension of native and non-native speakers of English.

Cloze test has been investigated in several studies for its concurrent validity as a measure of specific or general reading comprehension for both native and non-native English speakers. Contradicting results have been obtained when the cloze test has been used to measure reading comprehension of native English speakers. When the cloze test has been used to measure reading comprehension of non-native speakers of English, general results have indicated that it is a valid measure of specific and general reading comprehension.

Many cloze test studies have been undertaken to investigate the cloze test construction methods -- the length of cloze passages, the type of deletions to be made, the rate of deletions and the total number of deletions. Cloze scoring procedure has also been a subject of interest. There has been no definite answer as to whether an exact-word scoring procedure is preferable to an acceptable-word scoring procedure, when the subjects involved are non-native speakers of English.

Previous studies on cloze procedure with non-native English speakers reviewed so far have generally dealt with general English reading materials. Little has been done to use the procedure on science reading materials at the university level and with science students.

The present study therefore includes an attempt to establish the concurrent validity of the cloze test as a measure of specific reading comprehension and to investigate two different scoring procedures, when the procedure is applied to scientific English passages and with non-native English science students at the university level.

CHAPTER 2

RESEARCH DESIGN

Introduction

The purpose of this chapter is to present an account of: (i) the research questions which this study seeks to answer, (ii) hypotheses, (iii) the subjects, (iv) the instruments used, (v) the methods employed to collect data, and (vi) the procedures by which the data were analyzed.

Research Questions

During the nineteen fifties and sixties, reading in ESL/EFL was neglected because the audio-lingual approach to foreign language teaching attracted greater interest (Brumfit, 1977; Lim Kiat Boey, 1976; Norris, 1975; O'Donnell, 1974; Wilson, 1973). The audio-lingual approach, in placing heavy emphasis on speaking skill, assumed that reading and writing skills would follow "naturally" (Fries, 1963). In the seventies, with less emphasis placed on strictly audio-lingual techniques, attention came to be refocused on the reading component. The focus, however, tended to be put on reading at advanced rather than elementary levels (Berman, 1975). This came to be characteristic of the field of teaching English for Science and Technology (EST) also.

In recent years, the need of science students to comprehend scientific English textbooks has become a major concern among linguists and TESL/TEFL researchers. Their contemporary attempts have been directed at investigating: (i) reading at the discourse level rather than at the sentence level, and (ii) textual grammar rather than sentence grammar (Davies, 1979). The distinction between textual grammar and sentence grammar is significant. Textual grammar involves logical-rhetorical categories such as conjunction and reference, sentence grammar on the other hand is largely concerned with linguistic categories such as nouns and verbs (Davies, 1979, p.124). The basic and often unstated assumption underlying discourse analysis approach to the study of EST characteristics was that the subjects at the advanced level had a good command of sentence grammar. Accordingly, what was thought to impede them in comprehending longer scientific English discourse, was lack of knowledge of the rhetorical devices which science writers used to communicate their

intended message (Selinker et al., 1976).

The need for science students to learn rhetorical devices in order to comprehend EST texts has been emphasized in EST teaching. Yet a major problem seems to arise when the reading in EST has to be taught to students whose English language proficiency may be at either an advanced level or relatively low level. Predictably, the latter would have difficulty in understanding meaning not only beyond the sentence level but even at the sentence level (Eskey, 1970; Pierce, 1973). The question implied is, how could science students comprehend longer scientific English discourse when they had not even mastered the ability to comprehend English at the sentence level?

ESL/EFL readers, when reading advanced textbooks, are faced with various types of English structures, simple as well as complex. Observation has indicated that many of them tend to cause difficulty for ESL/EFL readers (Eskey, 1970; Pierce, 1973; Perkins & Yorio, 1974). Previous studies both of native and non-native English speakers have already confirmed, perhaps not surprisingly, that English complex structures are more difficult than simple ones. What has not yet been established is: (i) the relative comprehensibility of various types of English complex structures for ESL/EFL readers, and (ii) the relative comprehensibility of the various manifestations of a given type of English complex structure for ESL/EFL readers.

Three types of English complex structures have been selected for investigation in the present study. They are the complement, relative and comparative structures. They were selected on the assumptions that (i) they are involved in the embedding transformation, the process which has been shown to increase sentence complexity and cause difficulty to readers, (ii) they occur in EST and are faced by science readers, and (iii) they tend to be difficult structures for Thai students to learn. The author of the present study has to admit however, that this selection still leaves unexamined other structures which would also be difficult for Thai students and which should ideally, be investigated. However, given the time and resource available, only a limited number of structures could be encompassed. The selection made depended to some extent on the basis of the author's experience teaching English to Thai science students. That experience together with the criteria described above led to the conclusion that the three types of English complex structures mentioned

earlier were worthy of investigation first.

Observation and experimental studies on second or foreign language learning have both indicated that (i) English complex structures which include complement, relative and comparative structures are difficult for ESL/EFL learners to learn (Boonswasdi, 1978; Dušková, 1969; Eskey, 1970, 1975; Nilagupta, 1977; Pierce, 1973; Schachter, 1974; Srivicharn, 1978; Tachasansakul, 1978) and (ii) different manifestations of relative structures are not equally difficult to learn (Schachter, 1974; Perkins & Yorio, 1974). However, information on the relative comprehensibility of complement, relative and comparative structures and on the relative comprehensibility of different manifestations of each of these three types of English complex structures for ESL/EFL readers has not yet become available. Careful examination of second or foreign language learning research which investigated the difficulty of English grammatical structures for ESL/EFL learners does provide some explanation for such a lack. These are dealt with in turn below.

First, the approaches used to study the concept of the difficulty of English grammatical structures tend to be derived from different theoretical backgrounds and have different orientations. For example, the contrastive analysis approach attempts to determine the degree of difficulty of English grammatical structures on the basis of the degree and type of difference between Language 1 and Language 2. By contrast, the error analysis approach attempts to determine the degree of difficulty of English grammatical structures on the basis of the learner's errors -- errors mainly from speech or written samples. As a result, English relative clauses, for example, which were predicted by the contrastive analysis approach to be more difficult for the Japanese and Chinese learners than for the Persian and Arab learners, turn out, on the basis of error analysis approach, to be far less difficult for them (Schachter, 1974). Nevertheless, the interpretation made by an error analysis approach might be erroneous for, as Schachter points out, it fails to take into account the avoidance phenomenon. Schachter stated that:

... they produce fewer relative clauses in English because they are trying to avoid them, and that they only produce them in English when they are relatively sure that they are correct, which would also account for the extremely small number of errors they make (p.210).

Second, the term "difficulty to learn" used in second or foreign language learning research has been interpreted differently by different researchers. In some studies, the difficulty of English grammatical structures has been determined in terms of the learner's productive skills (Dušková, 1969; Schachter, 1974; Scott & Tucker, 1974). In other studies, the difficulty of English grammatical structures has been determined in terms of the learner's receptive skills (Boonswasdi, 1978; Cooper et al., 1979; D'Anglejan & Tucker, 1975; Nilagupta, 1977; Srivicharn, 1978; Tachasansakul, 1978; Perkins & Yorio, 1974). It is still unclear whether certain types of English grammatical structures which ESL/EFL learners found difficult to produce in speaking and writing, would also be found difficult to comprehend in reading, -- especially where "to comprehend" means getting meaning out of particular types of English structures rather than knowing their correct usage.

Third, different researchers have focused on the difficulty of different types of English complex structures. Perkins and Yorio (1974) investigated such complex structures as passive constructions, relative clauses, sentence nominalizations and ambiguous sentences using gerundive and participial constructions. For Schachter (1974), English complex structure covered only relative clauses. For Nilagupta (1977), the English complex structures covered, were passive constructions, relative clauses, complement and comparative structures. In the latter study, English complement, relative and comparative structures were examined. However, the attempt to determine their relative comprehensibility has not been made. Nilagupta's (1977) study which attempted to find if there was any relationship between syntax and the readability of English sentences for Thai learners, was only exploratory and was not well designed.

Fourth, many studies of the difficulty of English grammatical structures focused on different groups of ESL/EFL learners. Perkins and Yorio's (1974) study reported that advanced ESL learners did not find English complement and relative structures difficult to understand. Their findings cannot be generalized to another group of ESL/EFL learners whose language is different and whose level of English language proficiency varies.

There is then, a certain lack of coherence in the field. There is the theoretical controversy over the concept of "difficulty" in second or foreign language learning and teaching and there are different inter-

pretations of the term "difficulty to learn". As well, different types of English complex structures interest different researchers differently, while different groups of learners yield different results on the difficulty of English structures. No clear cut evidence on the relative comprehensibility of English complement, relative and comparative structures is obtainable.

In the field of second or foreign language teaching, the concept of "difficulty" is not the only criterion used to select linguistic items to be taught. The concept of "frequency of occurrence" has been also accepted as another (Mackey, 1969). The assumption underlying this notion is that what is taught should be useful to the learners. Usefulness, in this case, is often associated with the frequency of occurrence of linguistic items in the variety of the language to be studied. Influenced by this notion, attempts have been made in EST linguistic research to find which English lexical items and grammatical structures occur the most frequently in EST. It is assumed that those lexical items and grammatical structures which have been found to be distinctive of EST are likely to be of greatest utility and therefore of greatest need of attention for science learners (White, 1974). Very little attempt has been made, however, to see whether those English grammatical structures which occur most frequently in EST are comprehensible for science students.

Reading ability and its relationship to reading comprehension have also been of interest to researchers of reading. Attempts have been made to investigate the characteristics of good and poor readers. The rationale underlying such attempts was clearly described by Golinkoff (1975-76):

One way in which this analysis may be useful is to provide the theoretician with a sense of what a model of comprehension must encompass. Often, as Glaser (1973) has written, studying the skilled performer of a cognitive task does not lend itself well to analyzing the processes involved in the performance of that task. Task subskills may be so integrated and automatic that components of the process may be overlooked. Comparing readers at various stages of the acquisition process, however, may assist researchers in their analysis of the skill. Furthermore, a comparison of good and poor comprehenders may help researchers select issues of pragmatic importance. If certain aspects of the

process seem more difficult than others, researchers may gain insight into the more critical components of the skill. They may also gain information on how subskills are integrated. Finally, contrasting good and poor comprehenders may have pedagogical implications. To design reading comprehension instruction for the beginning reader or for the reader requiring remediation, it may be useful to determine at what points in the process good and poor comprehenders do and do not diverge (p.626).

Evidence from previous studies on good and poor readers has revealed that good readers: (i) seem to be capable of rapid and accurate word recognition (Golinkoff & Rosinski, 1976), (ii) read at least in phrase-like units (Cromer, 1970) and incorporate material outside phrases, clause or sentence boundaries during the reading process (Kolers, 1971; Willows, 1974), and (iii) are adaptable and flexible in their pattern of reading -- they vary their eye movements, shift the size of their processing units and efficiently use supplementary contextual information (Steiner, Wiener, & Cromer, 1971). Poor readers, however, (i) are inadequate in decoding skills (Buswell, 1920; Clay & Imlach, 1971; Cromer, 1970; Fairbanks, 1937; Golinkoff & Rosinski, 1976; Perfetti & Hogaboam, 1975; Steiner et al., 1971; Weber, 1970), (ii) read text in a word-by-word manner (Cromer, 1970; Oaken, Wiener, & Cromer, 1971; Steiner et al., 1971), and (iii) tend to read all materials in the same way (Anderson, 1937; Levin & Cohn, 1968). Similar investigations of the characteristics of good and poor ESL/EFL readers have not as yet been attempted. Effort has however been made to (i) compare the reading processes of ESL/EFL readers and native speakers (Hatch, Polin, & Part, 1970; Oller & Tullius, 1973), and (ii) investigate the transfer of reading skills from the first language to the second language (Clarke, 1979).

Reading ability and its influence on the ease or difficulty of reading written materials has been quite a preoccupation of readability researchers. Bormuth (1968b) stated the basic problem:

A problem long plaguing researchers was the question of whether the features that influenced readability for poor readers also influenced the readability of materials for more able readers. If the same features

of language influence readability for both and by the same amount, then a single and fairly simple formula can be used to predict readability for all students, regardless of their level of accomplishment in reading. But if different features influence difficulty for students of differing levels of reading achievement or if the same features influence difficulty by different amounts, then we must develop more complex and materially different kinds of formulas (p.491).

Nonetheless in an earlier study (Bormuth, 1966), he had come to the conclusion that, regardless of the subjects' reading levels, the same features of language that causes difficulty for the able readers caused difficulty for the not so able. Scott (1976) who investigated the effect of reading ability on the readability of grammatical patterns for Black inner city first graders, provided evidence which supported Bormuth's finding. He found a significant relationship ($r = .43$) between the overall comprehension of grammatical patterns for students who differed in reading ability. Scott (1976) interpreted the .43 correlation:

... We would expect some of the patterns to be at similar levels of difficulty for the two groups (p.44).

The question as to whether reading ability has its effect on the comprehensibility of English complex structures for ESL/EFL science readers has not yet been asked.

On the basis of such previous studies, together with the awareness that the students of concern to the present study (i) will not have yet reached an advanced level of English language proficiency and (ii) need to be able to comprehend scientific English both at the sentence level and at the discourse level, the present study sets out with the following specific questions in mind:

1. Does there exist a relationship between the ability to comprehend longer passages of scientific English and the ability to comprehend complement, relative and comparative structures?

2. Within the respective groups of good and poor readers, are the patterns of the comprehensibility levels of complement, relative and comparative structures similar?
- 3.(a) What is the relative comprehensibility of complement, relative and comparative structures for good and poor Thai science readers?
- (b) What is the relative comprehensibility of different manifestations of complement, relative and comparative structures taken separately, for good and poor Thai science readers?

While the search for answers to these questions can be justified on the grounds of (i) an existing lack of information (ii) the potential usefulness of definitive answers, ideally something more than establishing the "facts" would be preferable.

For non-native English speakers the phenomenon of English language learning - whether general English or English for Science and Technology - is difficult. Currently it is not known what "causes" the difficulty although conjecture is freely available. Without knowledge of "cause" it is not possible to overcome learning difficulties. While it is not within the competency of the current thesis to advance a fully developed explanation of the difficulties, it can take two rather tentative and not particularly radical steps in the direction of explanation. To this end two hypotheses have been advanced. Discussion follows.

Hypotheses

A major concern of the present study is to detect empirically any difference in the comprehensibility levels of complement, relative and comparative structures for Thai science readers who differ in EST reading proficiency. One assumption basic to this concern is that sentence comprehension is a prerequisite for the comprehension of longer English discourse. This assumption is however testable - by measuring reading comprehension in relationship to grammatical capability.

On this point, the evidence comes almost entirely from native speaker studies. It shows that there exists a moderately strong relationship between reading comprehension and knowledge of sentence grammar. The correlation between these two variables is even higher in the few cases

when the subjects of investigation were not native speakers of English.

There is no reason to believe that a similar relationship will not exist for the (Thai) subjects of the present study. The first formal hypothesis then is that:

Hypothesis 1: Reading Comprehension is a function of Comprehension of English Grammatical Structures: the better the comprehension of English grammatical structures, the better the reading comprehension of scientific English passages.

This first hypothesis was then operationally defined as follows:

There is a significant positive correlation between the total scores from the Cloze Reading Comprehension Test and the total scores from the Test of English Grammatical Structures.

There is a certain logic to such a hypothesis. It would appear to be reasonable to assume that people who have an understanding of grammatical structures should be better equipped to deduce meaning in sentences than those who merely had to rely on intuition. If, in turn these sentences were treated so as to conceal the meaning (as the cloze test does) then the proposition should still obtain - the grammatically knowledgeable should do better.

While the argument above has some face validity, the compelling evidence has to be admitted that proficient native speakers generally have intuitively arrived at a more complex set of grammatical rules than grammarians themselves have yet been able to formulate (Chomsky, 1973). However, the subjects of the present study are not native speakers and few, if any, will have arrived at a suitably intuited form of rule-governed behavior with respect to English. Accordingly it seems reasonable to argue that those who have achieved a measure of grammatical understanding should have a better basis for deducing meaning than should those who have not.

The second hypothesis bears on the issue of the kinds of difficulties experienced by good and poor readers.

One of the questions which readability researchers have been regularly concerned with is whether the same features of language equally affect students at different levels of reading achievement. Evidence from previous studies on native speakers of English showed that general reading ability was not found to affect the readability of the same features of language investigated (Bormuth, 1966; Scott, 1976). Similar studies of non-native speakers of English are not available. Accordingly, the hypothesis for the present study then has to rely on previous native speaker studies.

The second formal hypothesis then is that:

Hypothesis 2: The comprehensibility of English structures is not a function of general reading ability: the relative difficulty of structures is the same for good readers as it is for poor readers.

This second hypothesis was operationally defined as follows:

English grammatical structures rank-ordered for difficulty respectively for good and poor readers will be positively correlated.

This relatively weak hypothesis is the result of lack of evidence on the relationship between reading ability and comprehensibility of complex structures when the subjects are non-native English speakers. At the moment, it cannot be claimed that there are actual developmental stages to be discerned in the way acquisition of understanding of English complex structures occurs. On face value, there should be. Some structures ought to be easier to acquire than others. If so it might reasonably follow that good readers would have better command of the easier structures while poor readers would have worse or none. However, there is some evidence that points in this general direction and shows that easier structures are indeed easier for both good and poor readers. D'Anglejan and Tucker (1975), in their study of the acquisition of complement structures by adult learners of English at two different levels of proficiency, beginner and advanced, found a similar developmental pattern for the acquisition of the structures investigated in their subjects. They concluded that "the degree of

linguistic complexity inherent in the sentences is indeed, as Brown (1973) speculated, a critical factor in determining the order of acquisition of certain grammatical features and that this factor operates in both native language and adult second language learning" (p.292). It seems reasonable therefore to predict that the relative difficulty of complex structures examined in the present study would be the same for good and for poor readers.

The present study also makes the assumption that different English grammatical structures vary in difficulty. This assumption has been confirmed by both first language learning research (Bormuth, Carr, Manning, & Pearson, 1970; Brown, 1971; Caramazza, Grober, & Yates, 1977; Clark, 1965, 1969; Cook, 1975; Fodor & Garrett, 1966, 1967; Garrett, 1970; Gough, 1965, 1966; Hakes, 1972; Herriot, 1969; Holmes, 1973; Johnson, 1970; Just & Carpenter, 1971, 1976; Martin & Roberts, 1966; Mehler, 1963; Reid, 1972; Richek, 1976-77; Slobin, 1966) and second or foreign language learning research (Brown, 1975; Bailey, Madden, & Krashen, 1974; Chaiyaratana, 1961; Cooper et al., 1979; Corder, 1967; Cook, 1973; D'Anglejan & Tucker, 1975; Dulay & Burt, 1972, 1973, 1974; Duškova, 1969; Ervin-Tripp, 1974; Fathman, 1975; Gaies, 1980; Gingras, 1978; Hanania & Gradman, 1977; Mace-Matluck, 1979; Nickel, 1971; Ravem, 1974a; Schachter, 1974; Scott & Tucker, 1974; Suwattee, 1971; Taylor, 1975). There has not been, however, clear cut evidence as to which type of English complex structures is more difficult to learn for ESL or EFL learners. Therefore there appears to be no basis for the present study to predict the relative comprehensibility of English structures investigated - especially where Thai science readers of EST are concerned.

The main purpose was to provide experimental evidence as to (i) which types of English complex structure Thai science readers find more comprehensible, and (ii) which type of manifestation of a given type of English complex structure they find more comprehensible.

Given the "state of the art" of research into reading in ESL or EFL plus the research questions of the present study and two related hypotheses, the design for the research took on the following character.

One university in Thailand, Khon Kaen University was to serve as the locus. Within it, first year science students were to serve as the population from which the empirical sample was to be drawn. The sample was then to be tested for (i) reading comprehension and (ii) grammatical

structures understanding. Accordingly appropriate tests had to be devised and once ready, administered. Subsequently the data had to be analyzed, interpreted and reported on. Details of the procedures entailed are given below.

Sample

The population of the present study from which the sample was to be drawn consisted of first year Thai science students at Khon Kaen University. The first year university level was chosen for two main reasons. Firstly, considerable time has been devoted to the teaching of reading in English at this level. Secondly, because the purpose of the present study was to investigate the comprehensibility levels of selected English grammatical structures which occur in scientific English, for good and poor Thai science readers; it was judged that the language of first year science textbooks written in English was sufficiently complex for this purpose. Selection of first year students followed as a logical consequence of this judgment.

The total number of first year students taking English language courses during the 1978-79 academic year was 663. Of these, 551 were studying in the science field. They came from the faculties of Medicine, Nursing, Science, Agriculture, Education (majoring in science) and Engineering. However, the engineering students were inappropriate for inclusion in the sample because they did not meet the criteria of taking all three science subjects of the study - Physics, Chemistry and Biology (Biology did not feature in the engineering course). Accordingly the engineering group was excluded. The sample remaining numbered 384.

Table 2 shows the total number of students from each faculty, the number of students expected to be involved in the study and the actual number of students who participated in this study.

Table 2

Sample by Faculties

Faculties	Total no. of students	65% of students required	Actual number of students who participated in the study
Engineering	167	-	-
Medicine	30	20	18
Nursing	100	65	62
Agriculture	119	77	47
Science	91	59	41
Education (Majoring in Science)	44	29	28
Total	551	250	196

For the purposes of the study it was considered that a sample of 250 would be sufficient (Asher, 1976). Furthermore, the sample would be large enough to be handled practically for test administration. However, when the first test was administered, only 196 students were present. Over the remaining tests six more students were lost. Finally, 190 students were involved in the four tests. However, the number of students can be regarded as relatively representative of the science population at Khon Kaen University.

Composition of the sample

Among 190 students who were involved in this study, one was of 17 years, 74 were between 18 to 19 years. One hundred and nine had an age range between 20 to 21 years while the other six were between 22 to 23 years (see Table 3).

Of these 190 students, 80 were males and 110 were females (see Table 3).

Table 3
Sample Composition: Age and Sex

Age (years)				
16-17	18-19	20-21	22-23	Total
1	74	109	6	190

Sex		
Male	Female	Total
80	110	190

As a major focus of the present study was on Thai science students whose reading proficiency in EST is different, two reading ability groups were identified from the 190 students for the final analysis. The selection was based on the cloze reading scores (see the details in Chapter 5). The detail of age and sex of good and poor readers is presented in Table 4.

Table 4
Composition of Sample x Age and Reading Ability

	Age (years)		
	18-19	20-21	Total
Reading Ability			
Good Readers	18	22	40
Poor Readers	15	28	43
Total	33	50	83

Composition of Sample x Sex and Reading Ability

	Sex		Total
	Male	Female	
Reading Ability			
Good Readers	19	21	40
Poor Readers	23	20	43
Total	42	41	83

Instruments

The present study was conducted with an interest in science readers whose reading proficiency in English is different. A test to measure EST reading proficiency is therefore needed to distinguish good from poor readers. Accordingly, a cloze reading test was devised. Although the cloze technique has been tested for its concurrent validity as a measure of reading comprehension of non-native speakers of English, it is generally applied to general English reading materials. When the cloze technique is used in the present study - to measure understanding of scientific reading passages, it seems necessary to provide evidence as to whether it is also a valid measure of specific reading comprehension of EST reading materials. This led to the construction of another reading test -- applying the traditional multiple-choice technique.

Good and poor readers' comprehension of English complex structures encountered in scientific texts is a major focus of the present study. Accordingly, a test which measures comprehension of complex structures needs to be devised. The aim was to provide information concerning the strengths and weaknesses of good and poor readers in understanding complex structures. The test was constructed in a multiple-choice format. At this point, some doubt might be raised as to whether the test does measure "comprehension" of complex structures. To provide evidence to support the claim that the test measures "reading comprehension" of complex structures, another test which required the subjects to translate English sentences into Thai was constructed. The description of the tests follows.

Cloze Reading Comprehension Test

The Cloze Reading Comprehension Test was constructed on three passages each drawn randomly from three science textbooks used in the first year university level. The construction of the test, the psychometric properties of the test are described in Chapter 3 and 4. The test was used to measure Thai science students' reading comprehension of scientific English passages. It was to provide the basis for discriminating between good and poor readers.

Multiple-choice Reading Comprehension Test

The Reading Comprehension Test with the traditional multiple-choice format was also constructed. The test was based on the same three reading passages used in the Cloze Reading Comprehension Test. The construction of the multiple-choice items and the psychometric properties of the test are described in Chapter 3 and 4. The test was used to measure Thai science students' reading comprehension of scientific English passages. It served as a criterion test on which the concurrent validity of the Cloze Reading Comprehension Test as a measure of specific reading comprehension could be based.

Test of Comprehension of English Grammatical Structures

The Test of Comprehension of English Grammatical Structures was constructed in a multiple-choice format over 45 English sentences drawn randomly from three basic university science textbooks. Of these 45 sentences, 15 sentences each were selected to represent English complement, comparative and relative structures. The selection of the target sentences, the construction of the test items, and the psychometric properties of the test are described in Chapter 3 and 4. The test was used to measure the comprehensibility levels of English complement, comparative and relative structures.

English-Thai Translation Test of Comprehension of English Grammatical Structures

The test was composed of the same 45 target sentences used in the Test of Comprehension of English Grammatical Structures. It was used to measure Thai science students' comprehension of English complement, comparative and relative structures. It also served as a criterion test on which a concurrent validity of the multiple-choice Test of English

Grammatical Structures could be based.

KKU English Language Proficiency Test

The test was constructed by the Department of Foreign Languages, Khon Kaen University, in 1974, (i) to assess first year university students' English language proficiency, (ii) to place the students into the appropriate English language levels and (iii) to exempt those students who have mastered English language skills from the compulsory English language courses. The test of 100 items in a multiple-choice format is composed of three main parts measuring vocabulary skills, knowledge of grammar and reading comprehension skills.

The test was administered to the subjects of the present study by the Department of Foreign Languages, Khon Kaen University, at the beginning of the 1978-79 academic year. The scores from the Vocabulary Sub-test were therefore obtained from the Department. The scores served as the third variable in the partial correlations carried out to examine if the relationship between the grammatical structure scores and the cloze scores, and between the grammatical structure scores and the multiple-choice reading scores was due to its effect.

Collection of the Data

The four tests were administered in four separate periods of approximately two hours each on July 22, 26, 30, 1979 by six lecturers. They were monitored by the author who explained the test instructions before the administration of each test.

Full details on the test administration are given in Chapter 4.

Treatment of the Data

Test scoring

The students' answers to the Cloze Reading Comprehension Test (the exact word scoring method), the Multiple-choice Reading Comprehension Test and the Multiple-choice Test of English Grammatical Structures were scored by a fourth year student who applied a pre-determined key.

The author scored the answers to the Cloze Reading Comprehension Test (the acceptable word scoring method) and the English-Thai Translation Test of English Grammatical Structures. Finally the SPSS program was used for

the statistical analyses on the Burroughs 6700 at Massey University.

Computation

Pearson-product moment correlation was used for three specific purposes:

- (i) In order to determine the relationship, if any, that existed between reading comprehension of scientific English passages and comprehension of English grammatical structures, Pearson-product moment correlations between the cloze scores and the grammatical structure scores were computed.
- (ii) To determine the concurrent validity of the Cloze Reading Comprehension Test, Pearson-product moment correlations between the cloze scores and the multiple-choice reading comprehension scores were also used.
- (iii) To determine the concurrent validity of the Multiple-choice Test of English Grammatical Structures measuring non-native English science students' comprehension of English grammatical structures, Pearson-product moment correlations between the multiple-choice grammatical structure scores and the translation scores were computed.

Partial correlations were carried out to examine if the relationship between the grammatical structure scores and the cloze scores, and between the grammatical structure scores and the multiple-choice reading comprehension scores was due to the effect of the third variable - the knowledge of word meanings.

To determine the degree of similarity between the rankings of the comprehensibility levels of 15 English structures for good and poor readers, a rank order correlation was computed.

To determine whether there was a significant difference in the comprehensibility levels of three types of English complex structures and in the comprehensibility levels of five manifestations of complements, comparatives and relatives, taken separately, single-factor analyses of variance with repeated measures were carried out.

T-tests were used to determine if there were any significant differences between males and females' mean scores on (i) the Test of English

Grammatical Structures, (ii) the Cloze Reading Comprehension Test, (iii) the Multiple-choice Reading Comprehension Test, and (iv) the KKU Vocabulary Sub-test.

Summary

The present study was designed to investigate the relationship between Thai science students' reading comprehension of longer passages of scientific English and their comprehension of English complex structures. This was to test that it is important for non-native English readers to possess syntactic information in order for the printed message to become meaningful to them.

The Cloze Reading Comprehension Test was used to measure Thai science students' reading comprehension of scientific English reading passages. In order to provide evidence of the concurrent validity of the Cloze Test as a measure of specific reading comprehension, a traditional reading comprehension test was also constructed. Pearson-product moment correlations between the cloze scores and the multiple-choice reading comprehension scores were computed.

Differences in reading ability, a matter of interest in this study, were determined on the basis of cloze reading scores.

In the course of investigating good and poor readers' comprehension of English complex structures, single-factor analyses of variance with repeated measures were computed to see if (i) there were any significant differences between English complements, comparatives and relatives, and (ii) there were any significant differences in five manifestations of complement, relative and comparative structures taken separately, for both good and poor readers.

A Spearman rank-order correlation was also computed to see if there was a degree of similarity between the rankings of the comprehensibility levels of 15 English structures for good and poor readers.

CHAPTER 3

TEST CONSTRUCTION

In this chapter, the four tests developed for the present study are described in terms of their construction and their final test forms.

Construction of the Cloze Reading Comprehension Test

The test was constructed to measure Thai science students' reading comprehension of scientific English passages and to provide information about good and poor readers of scientific English.

Selection of the Sample Passages

The samples of prose material used as test passages were selected on the following criteria: (i) Passages should be representative of the kinds of material which the subjects would be expected to use in their first year academic science courses. For example, first year science students should be tested on samples taken from the text materials in current use in their first year science courses in Physics or Biology. (ii) The sample passage should be a self-contained meaningful passage. (iii) The sample passage should be long enough to provide a reliable measure of a student's performance but not long enough to introduce a significant fatigue factor. (iv) The sample passages should not have been read recently enough for rote memory to influence the student's word choices.

The heads of the Department of Physics, Biology and Chemistry in the Faculty of Science, Khon Kaen University, were consulted as to the representativeness of both the science textbooks used at the first year level and the sample passages selected from them. Letters were sent asking each Department Head to provide a list of science textbooks used at the first year level. Each was also asked to suggest the most important text which he/she thought covered the content of the course and which he/she expected the students to use. Their answers revealed that the following science textbooks were common to first year science students from all faculties included in this study:

- (i) Weisz, Paul B. The science of Biology. New York: McGraw-Hill Book Company, 1971.
- (ii) Alonso, M. and Finn, E.J. Physics. Addison-Wesley Publishing Company, Inc., 1972.
- (iii) Kice, John L., and Marvell, E.N. Modern principles of organic chemistry - an introduction. New York: MacMillan Publishing Company, Inc., 1974.

A sample passage was taken from each textbook. A table of random numbers was initially used to select the sample passages. Any sample passages which met all of the above criteria was adopted as the test passages. To illustrate, for the selection of the passage on "Molecular Diffusion" from the Physics text, the author chose at random from a Table of Random Numbers, three columns, (in this case 4, 5, 6) to obtain a series of numbers 793 246 327 282 578. These numbers served as the page numbers of the Physics text. Page number 793 was found to be unsuitable because the text covered only page 2 to page 735. The author next looked up the page 246. The passage was not a self-contained meaningful passage so it was rejected. Page number 327 was next considered. It was also rejected because there was no reading passage on that page. The author then moved on to page 282. Here the passage was found to be a self-contained meaningful passage and long enough to provide a reliable measure. The head of the Physics Department confirmed that the passage had not been recently read by first year science students.

The three test passages selected for the Cloze Reading Comprehension Test were:

- (i) "Parasitic Reproduction" from Weisz, Paul B. The science of Biology, p.108.
- (ii) "Molecular Diffusion" from Alonso and Finn. Physics, p.282.
- (iii) "Covalent Bonds" from Kice and Marvell. Modern principles of organic chemistry - an introduction, p.6 (see Appendix A).

Construction of Cloze Items

In light of the results of the studies on cloze procedure reviewed in Chapter 1, the author made the following decisions with regard to the use of the cloze procedure to measure the students' reading comprehension:

- (i) Every seventh word including both structural and lexical words, starting from the first sentence of the second paragraph of each passage, was deleted. This decision was made as a result of a first pilot testing of the cloze procedure involving four Thai postgraduate science students studying at Massey University, New Zealand, on July 8, 1978. The result indicated that the passage in which every fifth word was deleted caused more fatigue and difficulty than the same passage in which every seventh word was deleted.
- (ii) Specific scientific terminology "covalent bond", which appeared on lines 18-19 of the passage "Covalent Bonds", and the number of the figure "Fig. 14.1" which appeared in the passage "Molecular Diffusion" on line 20 were not deleted.
- (iii) A standard underlined blank (10 typewriter spaces) was inserted for each word deleted.
- (iv) Concerning the number of items in a cloze test, such considerations as test time, fatigue, and test reliability were considered. As previous studies indicated, a cloze test containing about 50 items gave a satisfactory degree of reliability (Bormuth, 1965; Taylor, 1956). Selecting one long passage from one science text which contained 50 items would suit the requirement. However the purpose in constructing the test was to measure students' reading comprehension of science passages in three different science areas. An effort was thus made to construct 30 cloze items for each of the three passages. This resulted in a cloze test with 90 deleted items.

Pilot Testing II

The purpose of the second pilot testing was to obtain information on two cloze scoring procedures (an exact word scoring procedure and an acceptable word scoring procedure), to check the test instructions, to find out the reliability of the test and the time taken to complete it.

Test sample

Sixty, first year science students from Mahidol and Kasetsart Universities, Bangkok took part in the pilot testing on February 10 and 15, 1979. Students from both Universities were chosen as representative

of the kinds of subjects of the present study. Choosing only medical students from Mahidol University would have introduced a distortion for, on the basis of the university entrance examination, they are known to be academically more able. Choosing only students from Kasetsart University would also have introduced a distortion as they did not fully cover the subject range of the students in the main study (medicine, science, agriculture, nursing and education). The 60 students were paid volunteers.

Test administration

The Cloze Reading Comprehension Test of 90 items was administered twice, first to a group of 27 students at Kasetsart University on February 10, 1979, second to a group of 33 students at Mahidol University on February 15, 1979. The test was administered exactly the same way to the two groups. Each student was given a test booklet and an answer sheet. The author explained in detail how to do the test, recording it in order to revise it, if necessary, for the final testing. There was no time limit set for the test so that the time needed to complete it could be gauged and to make sure that all blanks were completed so that the key to the acceptable words could be made. The students were encouraged to do the test the best way they could.

Scoring procedure

The students' answers to the test were hand scored by the author using two different procedures. The first employed the exact word scoring procedure where each exact replacement of a deleted word was given one mark. Incorrect spelling was not penalized as long as the word was recognizable. The second applied the acceptable word scoring procedure. For the latter, the researcher first prepared a list of all possible responses based on the result of the pilot testing. Then two native speakers of English, a scientist and a teacher of English as a foreign language, were consulted. This was to ensure that all responses were contextually acceptable and were also grammatically correct. By applying this procedure, each exact replacement of a deleted word and each response that was contextually acceptable was given one mark. Again incorrect spelling was not penalized as long as the word was recognizable.

Results

The results of the exact and acceptable word scoring procedures to the data collected from the 60 students are presented in Tables 5 and 6.

Table 5

Cloze Test (Exact Word Scoring): Basic Statistics

Test Variable	N	Mean	Median	Range	SD
Cloze Test (exact word scoring) (n = 90 items)	60	34.56	37	8-62	9.28

The Kuder-Richardson 20 reliability of the test was .86.

Table 6

Cloze Test (Acceptable Word Scoring): Basic Statistics

Test Variable	N	Mean	Median	Range	SD
Cloze Test (acceptable word scoring) (n = 90 items)	60	43.43	45	10-70	13.42

The Kuder-Richardson 20 reliability of the test was .88.

On the basis of the results, the test was taken to be reliable. It could distinguish students whose ability in reading comprehension was good from those whose reading ability was poor. The test was therefore accepted for use unmodified in the main study. It was composed of three scientific English reading passages, each with 30 cloze items (see Appendix A).

Construction of the Multiple-choice Reading Comprehension Test

The purpose of the test was to measure Thai science students' reading comprehension of scientific English passages. It was aimed to be used as a criterion test so that the Cloze Reading Comprehension Test could be tested for its concurrent validity.

Selection of the Test Passages

The sample passages used in this test were the same as in the Cloze Reading Comprehension Test. See page 86.

Construction of the Multiple-choice Items

Six comprehension skills normally listed in the cloze validity studies as measures of specific reading comprehension (Anderson, 1976; Bormuth, 1967; Rankin & Culhane, 1969) were adopted for the present study. They were: knowledge of vocabulary used in the passage; knowledge of stated facts; ability to perceive causal relationships; ability to grasp the organization of a passage; ability to make inferences and ability to identify the main idea.

The number of the test items devoted to each skill is stated in the table of specification (Table 7).

For testing the first of these (the knowledge of vocabulary used in the passage), 14 vocabulary test items were originally constructed from each passage. The selection of the test words was made on the basis of West's A General Service List of English Words (1953). In the passage, each test word was underlined and assigned a number. The purpose was to help the student easily identify the test word in the test booklet and its context in the passage. In the test booklet, each test word was provided with four multiple-choice responses, one of which was the right or best meaning of the test word. Considerable effort was made in the present study to construct effective multiple-choice responses in accord with authorities on language testing (Harris, 1969; Heaton, 1975; Lado, 1961; Smith, 1970; Valette, 1967) namely:

1. All choices should fulfil the same grammatical function as the problem word or phrase. For example, a verb should have verb distractors:

Table 7

Comprehension Specifications

Reading Passage	Six Comprehension Skills						Total number of items
	Know vocabulary	Know stated facts	Understand causal relationships	Be able to make inferences	Understand the organisation of the passage	Identify the main idea	
Molecular Diffusion	8	4	3	2	2	1	20
Covalent Bonds	8	4	3	2	2	1	20
Parasitic Reproduction	8	4	3	2	2	1	20
Total number of items	24	12	9	6	6	3	60
Percent of items	40	20	15	10	10	5	

- to acquire: *(a) to get
 (b) to attend
 (c) to add
 (d) to give

(Covalent Bonds - Item23)

2. The choices in each item should be approximately the same length or be paried by length,

- e.g. diffuse (a) occur
 *(b) spread
 (c) expand
 (d) reduce

(Molecular Diffusion - Item43)

- or partition (a) space
 (b) remaining substance
 (c) vessel
 *(d) dividing wall

(Molecular Diffusion - Item46)

3. All choices should be on approximately the same level of difficulty. This was controlled by using:

- (i) the frequency of occurrence as tabulated in West's A General Service List of English Words (1953) as a guideline for the level of difficulty,

- e.g. involved *(a) concerned
 (b) provided
 (c) needed
 (d) added

(Covalent Bonds - Item22)

The frequency of occurrence of these four words were 353, 479, 682 and 417 respectively. It should be emphasized here that the frequency of occurrence was not regarded as the only important factor for judging the difficulty of multiple-choice responses.

- (ii) the author's judgement based on 10 years of experience as a language teacher of Thai science students,
 - (iii) the judgements of two language specialists.
4. All choices should be made plausible and attractive to students who lack the knowledge tested by the item. To achieve this task, other criteria were also applied in this study:

- (i) Whenever possible, all choices should be related to the same general area or kind of activity,

e.g. matures (a) increases
 *(b) develops
 (c) produces
 (d) lives

(Parasitic Reproduction - Item 8)

Here all four choices belong to the same general area of "living or growing"

- (ii) Whenever possible, one choice should be opposite in meaning to the test word ,

e.g. encapsulates (a) breaks a capsule
 (b) leaves a capsule
 (c) digests a capsule
 *(d) builds a capsule

(Parasitic Reproduction - Item 7)

The distractor is (a).

- (iii) In cases where the test word has several meanings, one or two choices should be devised from other contextual meanings of the same word,

e.g. manner (a) custom
 (b) appearance
 *(c) way
 (d) behavior

(Covalent Bonds - Item 24)

- (iv) Whenever possible, one choice should be a context-induced distractor. That is, it should fit the context although it does not have the same meaning as the test word,

e.g. eventually (a) certainly
 (b) usually
 (c) possibly
 *(d) finally

(Molecular Diffusion - Item44)

The context where the word "eventually" appears was like this,
 "The sugar dissolves gradually, but at the same time the dissolved sugar molecules diffuse through the water, and eventually are distributed throughout the water."

Here the distractors (a), (b), (c) were context-induced distractors.

They fit the context

"The dissolved sugar molecules _____ are distributed throughout the water."

For testing the other five comprehension skills, 16 multiple-choice items were originally constructed for each passage. Out of these 16 items, six were designed to test knowledge of stated facts, four to test ability to perceive causal relationships, three to test ability to make inferences, two to test ability to grasp the organisation of a passage, and one to test ability to identify the main idea of a passage.

The content of each passage was first "mapped" (Hanf, 1971) to establish main ideas, secondary categories and supporting details. Figure 1 "mapped" the ideas of "parasitic reproduction", while Figures 2 and 3 "mapped" those of "molecular diffusion" and "covalent bonds" respectively. This was designed to facilitate the preparation of questions. Examples of the question types for testing these five comprehension skills follow:

- (i) To test the knowledge of stated facts
 e.g. What happens after we remove the partition?

(Molecular Diffusion - Item 52)

- (ii) To test the ability to perceive causal relationships
e.g. Why can't a tapeworm egg transfer directly from one human host to another human host?

(Parasitic Reproduction - Item 14)

- (iii) To test the ability to make inferences
e.g. What is the writer's purpose in giving us examples in the passage?

(Molecular Diffusion - Item 56)

- (iv) To test the ability to grasp the organisation of the passage
e.g. How did the writer explain the concept of "molecular diffusion"?

(Molecular Diffusion - Item 58)

- (v) To test the ability to identify the main idea
e.g. Which is the main idea of the passage?

The construction of the item stems and the multiple-choice responses was made in accordance with the following general criteria:

- (i) Each item should begin with either a stem question or incomplete statement to which a reasonably adequate answer or completion can be given concisely and for which plausible wrong answers can be found.
- (ii) Each item should be independent of all others. Using related items in which the answer to one may unwittingly solve another should be avoided.
- (iii) Each item should not be capable of being answered from the reader's general knowledge, without reference to the passage.
- (iv) Each of the multiple-choice responses should be appropriate to the question asked or implied by the item stem.
- (v) All multiple-choice responses should be parallel in grammatical structure, in type of content, in length and in complexity.

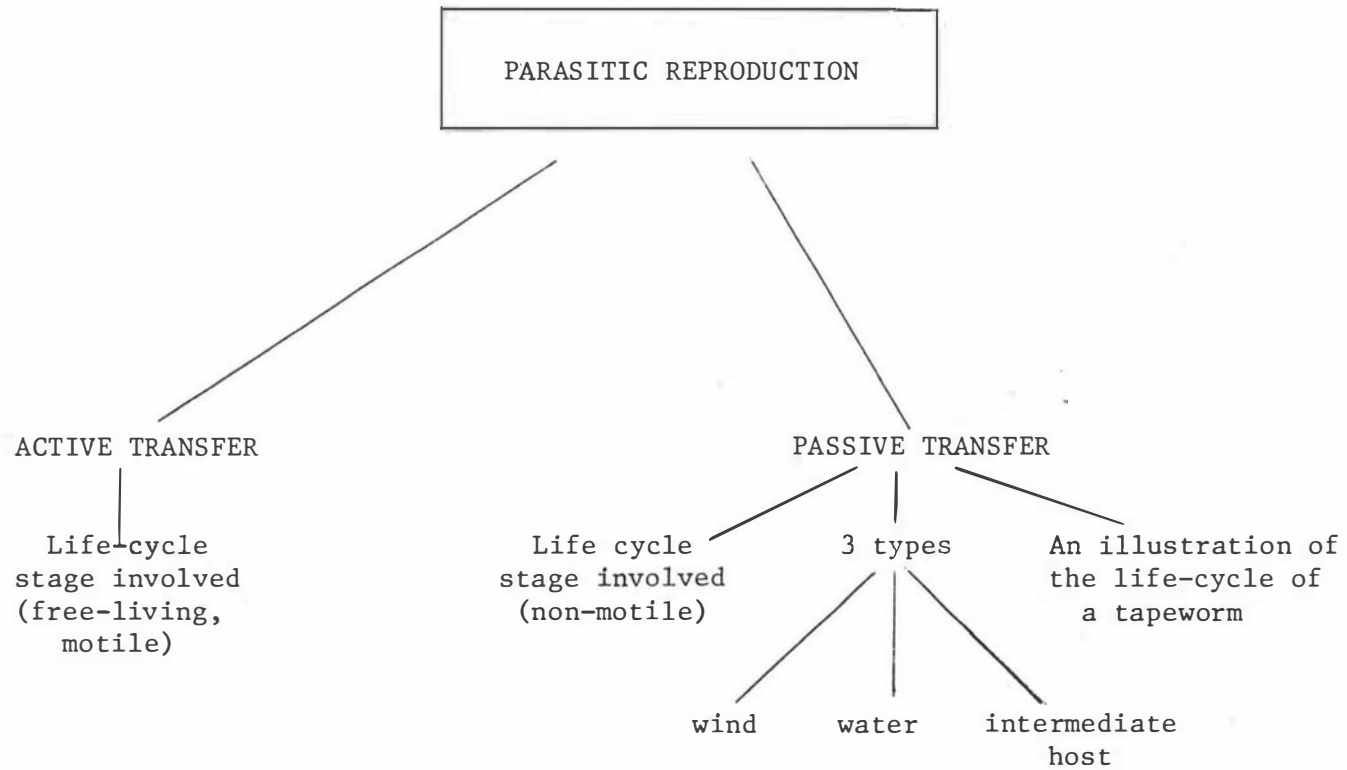


Figure 1. Map of the main idea, secondary and supporting details of the passage from the Biology text, "Parasitic Reproduction".

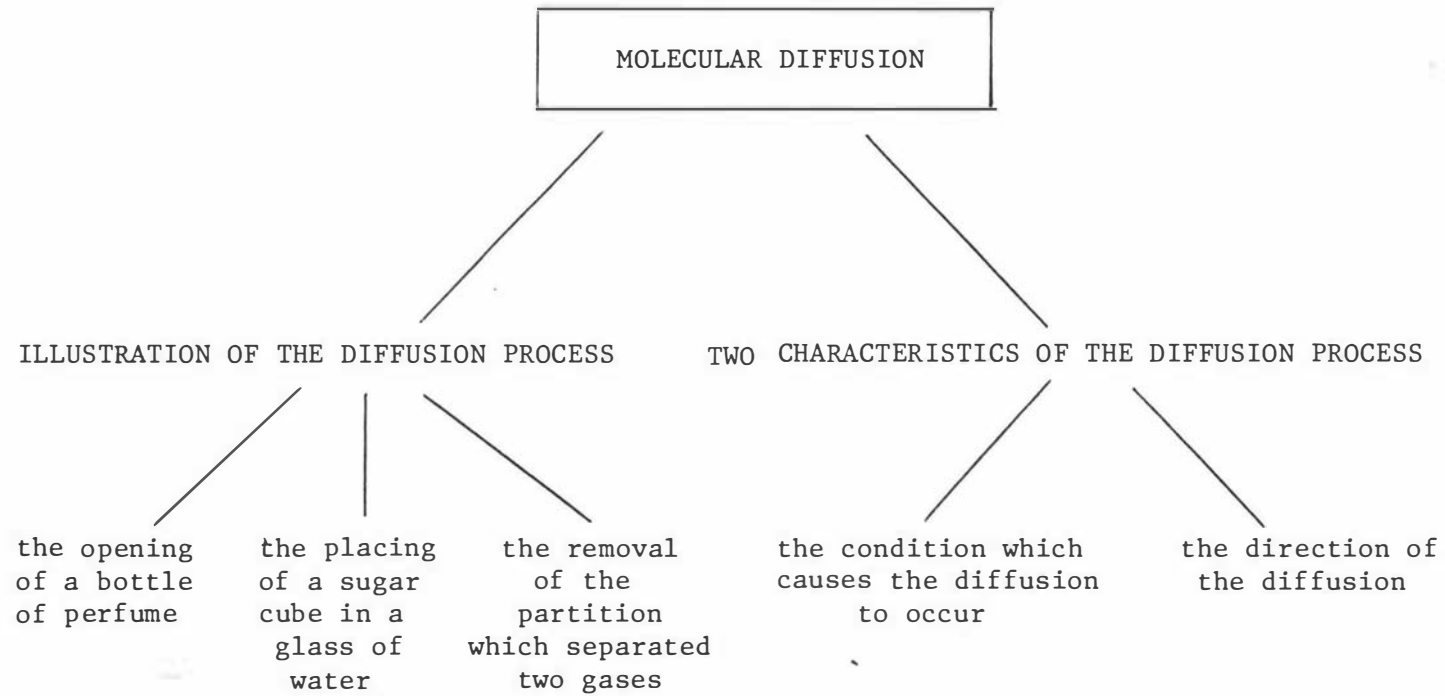


Figure 2. Map of the main idea, secondary and supporting details of the passage from the Physics text, "Molecular Diffusion".

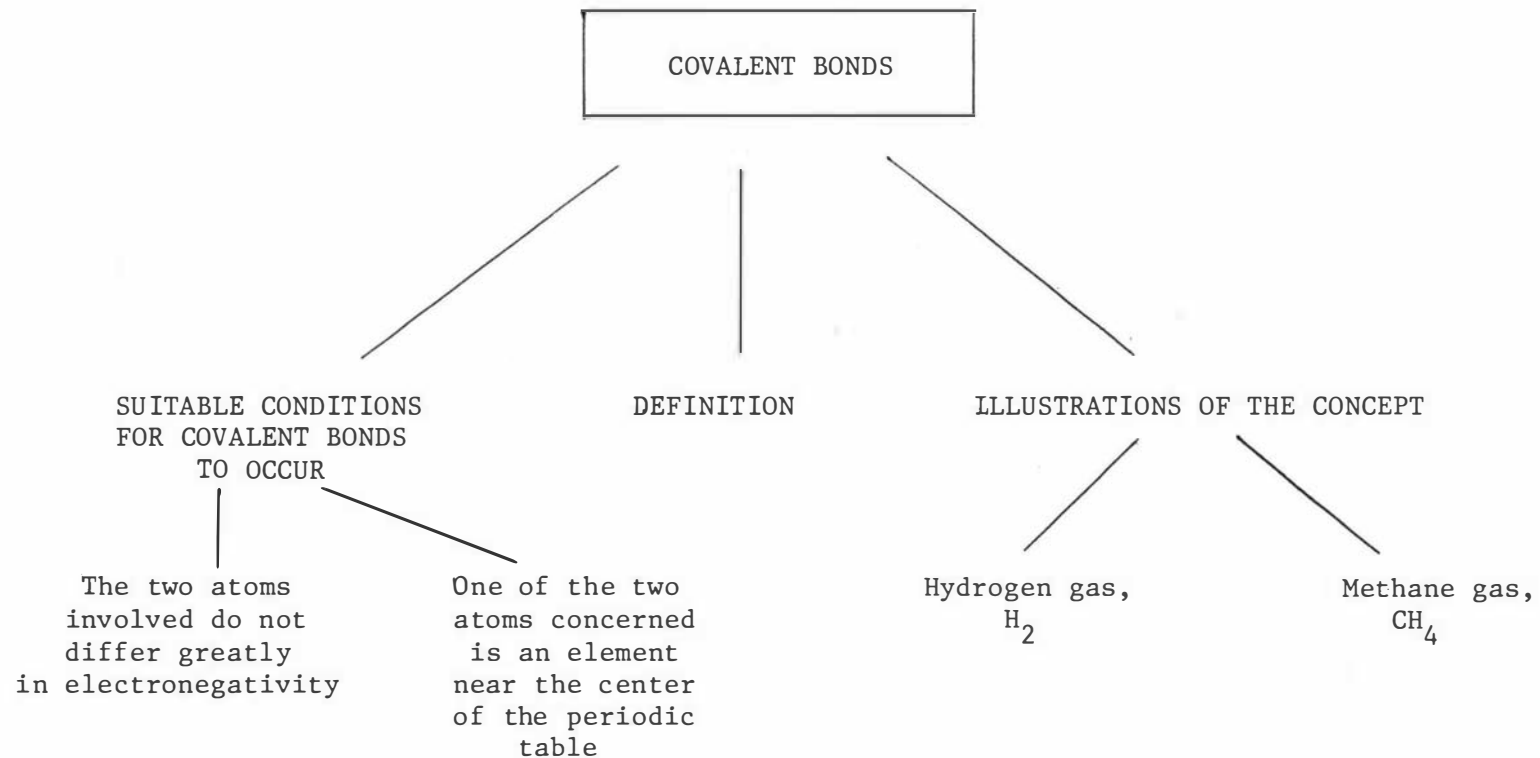


Figure 3. Map of the main idea, secondary and supporting details of the passage from the Organic Chemistry text, "Covalent Bonds".

For constructing the plausible distractors, this study followed Schlesinger and Weiser's (1970) concept of strengthening the relationship between the test item and the text on which it is based. Schlesinger and Weiser differentiate between three basic categories of distractor statements as follows:

- (i) The distractor statement "agrees with information which is either explicit or implicit in the text, but is not an acceptable answer in the light of the correct choices."
- (ii) There is "no information in the text which is relevant to the distractor statement."
- (iii) The distractor statement "contradicts what is said either explicitly or implicitly in the text."

The way in which these principles for distractors were applied is illustrated below. The item and its alternative answers are featured first.

Item 34 (Covalent Bonds):

Why is carbon referred to in the first paragraph?

- * (a) To illustrate that a complete transfer of an electron from one atom to another is not a suitable way for carbon to acquire a rare gas configuration.
- (b) To illustrate that the electronegativity of carbon is great.
- (c) To illustrate that carbon forms four covalent bonds through the sharing of four electron pairs with other atoms.
- (d) To illustrate that a process of electron sharing is not favorable for carbon to achieve filled outer shells.

Distractor statement (c) has been made explicitly in the text (see Appendix B on page 255 lines 27-29), however it is not an appropriate answer. Distractor statement (d) is contrary to what is stated explicitly in the text (see Appendix B on page 255 lines 12-13). As for (b), the text has no information which is relevant to this distractor statement.

When the original 90 items were constructed, they were first reviewed by the author and were then submitted to one native English speaking scientist and to two other science lecturers who were speakers of Thai. The purpose was for the subject-matter experts to check the accuracy and the appropriateness of the science content which lay both in the questions and in the response choices. Their comments helped in the revision of the test items at this initial stage. The revised test was next submitted to five other language specialists. Three were native speakers of English. The other two were native speakers of Thai. They helped in editing the test in terms of the correct use of the language and in making judgements of the quality of the questions which were aimed at testing particular comprehension skills.

Pilot Testing I

The purposes of the pilot testing were (i) to test reliability, (ii) to check the accuracy of the instructions and (iii) to improve the quality of the test items by item analysis.

The 54 first year science students from Mahidol and Kasetsart Universities, Bangkok who took part in the Cloze Reading Comprehension Test undertook this pilot testing also.

Test administration

The test of 90 items in a multiple-choice format was administered twice, first to the 22 students at Kasetsart University on February 17, 1979, second to the 32 students at Mahidol University on February, 22, 1979. The test was administered exactly the same way to both groups. Each student was given a test booklet and an answer sheet. The author explained in detail on how to do the test and made sure that everybody understood it. There was no time limit set for the students to complete the test. This was to ensure that all test items were completed by all.

Scoring procedure

The student answers to the test were hand scored by the author using the key to the correct answer which was prepared in advance. Each correct answer was given one mark.

Results

The results of the test administered to the 54 first year science students are presented in Table 8.

Table 8

Multiple-choice Reading Comprehension Test: Basic Statistics
Pilot Testing I

Test Variable	N	Mean	Median	Range	SD
Multiple-choice Reading Comprehension Test (n = 90 items)	54	61.8	62.5	40-81	8.1

The Kuder-Richardson 20 reliability was .78.

To improve the quality of the test, the high-low 27 percent method of item analysis was carried out. The difficulty indices and the discrimination indices of the test items were obtained from Chung-Teh Fan's Item Analysis Table (1952). The following item statistics of the test resulted:

- (i) The item difficulties ranged from -.27 to .99. Thirty-two items had difficulty indices of greater than .80. Fifty-six items had difficulty indices in the range of .20 to .80. Two items had difficulty indices of less than .20.
- (ii) The item discrimination indices ranged from .00 to .76. It was found that 11 items had coefficients greater than .40. Forty-one items had discrimination indices in the range of .20 to .40. Thirty-eight items had coefficients of less than .20.

To improve the quality of the test, those items which had discrimination indices of less than .40 were either rejected or revised. Items having a validity index at .40 and up were considered good (Ebel, 1979, p.267).

As a result of this pilot testing, a revised test of three reading passages was constructed containing 24 vocabulary items, 12 fact items, nine items for relationships, six items for each of inferences and organization of the passages and three main ideas, an equal number of each type of item from each passage.

Pilot Testing II

The purposes of the second pilot testing were:

(i) to test reliability and (ii) to improve the quality of the test by item analysis.

Test sample

The sample used in the second pilot testing consisted of 124 first year science students from Chiangmai University. They were chosen because they had science knowledge backgrounds and English language backgrounds similar to science students at Khon Kaen University (the subjects of the present study) and because they were accessible and co-operative. These 124 students were from the faculties of Pharmacy, Technical Medicine, Science, Nursing and Education (majoring in science). They were all paid volunteers.

Test administration

The revised test of reading comprehension was administered to a group of 124 science students in an afternoon session on June 30, 1979. Before the test was taken, three lecturers to be used as proctors met with the author so that the test instructions could be made clear. The students were placed into two separate rooms, with two proctors in one and the author and one proctor in another. Each student was given a test booklet with an answer sheet. There was no time limit set for the students to complete the tests so that the amount of time taken to complete the whole test could be gauged and to ensure that all items were completed.

Scoring procedure

The students' answers to the 60 test items were hand scored by the author, using the key prepared in advance. Each correct answer was given one mark.

Results

The results of the test administered to the 124 science students at Chiangmai University are presented in Table 9.

Table 9

Multiple-choice Reading Comprehension Test: Basic Statistics
Pilot Testing II

Test Variable	N	Mean	Median	Range	SD
Multiple-choice Reading Comprehension Test (n = 60 items)	124	29.6	29.5	12-56	8.16

The Kuder-Richardson 20 reliability was .80.

The high-low 27 percent method of item analysis was applied to improve the quality of the test. The difficulty indices and the discrimination indices of the 60 test items were obtained from Chung-Teh Fan's Item Analysis Table (1952). The following item statistics of the test in the second pilot testing resulted:

- (i) The item difficulties ranged from .19 to .84. Two items had indices of greater than .80. Two items had indices of less than .20.
- (ii) The item discrimination indices ranged from .00 to .72. Sixteen items had coefficient greater than .40. Thirty items had discrimination indices in the range of .20 to .40. Fourteen items had coefficients of less than .19.

As those items which discriminated poorly between high and low achievers, measured the objectives specified in the test specification in the planning stage, they were kept for revision and none were omitted. An examination of the test items was made for the possible presence of ambiguity, clues and other technical defects. Then the revised items were retained in the final test.

The Multiple-choice Reading Comprehension test, in its final form, was thus composed of three reading passages of scientific English, each with 20 test items (see Appendix B). It was finally administered to the subjects of the present study on July 26, 1979.

Construction of the Test of English Grammatical Structures

The purpose of the test was to measure Thai science student levels of comprehensibility of five English complement, five English comparative and five English relative structures. These were represented by 45 sentences drawn randomly from three basic university science textbooks.

Selection of the 15 English Grammatical Structures

In the present study, three grammatical areas were first selected from Lee's (1975) classification of linguistic features in scientific English. The reasons for using Lee's method of classification were as follows. Firstly, Lee's study was concerned with the description of the linguistic characteristics of English for Science and Technology (EST) -- the kind of English language of interest to the present study. Secondly, his study attempted to investigate through a detailed linguistic analysis the relationship between syntax and the reading comprehension skills required in the usage of scientific English. The Lee study thus has provided data on the frequency of occurrences of English structures from which the selection of particular structures under investigation in the present study could be made. Thirdly, the corpus in Lee's study was based particularly on basic university science textbooks. The level of the textbooks was the same as that of the textbooks which the present study attempted to investigate. Fourthly, Lee's classification of English grammatical structures incorporated both a grammatical framework and a rhetorical framework. Such a detailed classification was directly relevant to the aims of the present study.

One of the purposes of Lee's study was to give as accurately as possible a picture of the English language used in science textbooks. Thus he included in his classification of linguistic features, nine grammatical areas of the English language system: mood, voice, basic structures, modality, complementation, relativization, comparison, adjunction and coordination. The first four grammatical areas (mood, voice, basic structures and modality) were concerned with simple or basic sentences. The other five grammatical areas dealt with "complex" sentences.

The present study was undertaken to investigate three grammatical areas of the complex sentence type -- complementation, relativization and comparison. The reasons for selecting these particular types of complex sentences have been stated elsewhere (see Chapter 2). Within each of these three grammatical areas, five English grammatical structures were then selected. The selection was based on Lee's data on the occurrences of English grammatical structures found in his corpus. The procedures for the selection of 15 English grammatical structures will be described in detail in the following sections.

Relative constructions in scientific English

Lee (1975) studied the syntax and function of relative clauses in scientific English under two separate headings: finite construction (restrictive or non-restrictive) and non-finite construction (restrictive or non-restrictive). Quirk and Greenbaum (1973) distinguished between the two constructions in the following way:

The finite clause always contains a subject as well as a predicate, except in the case of commands, and ellipsis In contrast, non-finite clauses can be constructed without a subject, and usually are ... (p.310)

The term "restrictive" and "non-restrictive" clauses were described by Lester (1971) as follows:

A restrictive modifier is one that, together with the noun it modifies, makes up a semantic unit different in kind from the noun by itself. A non-restrictive modifier is one that can be deleted from the sentence without radically changing the meaning of the whole sentence (p.221).

Table 10 shows the data from Lee's study on the relative frequency of occurrence of finite restrictive and non-restrictive clauses as well as that of non-finite restrictive and non-restrictive clauses. It reveals that in the passages he examined, there were 391 occurrences of non-finite relatives and 400 occurrences of finite relatives. Among the non-finite relative constructions, restrictive clauses were more frequently used than non-restrictive clauses (299 occurrences compared with 92). Accordingly, non-finite restrictive clauses were selected for the study. For the finite relative construction, restrictive clauses of finite construction

were more frequently used than non-restrictive clauses in the corpus (258 occurrences compared with 142). Therefore restrictive clauses of finite construction were selected for the study.

Table 10

Relativization (791)

Non-finite		Finite	
restrictive	non-restrictive	restrictive	non-restrictive
299	92	258	142

(Lee, 1975, pp.157-8, 161, 168)

1. Restrictive clauses of non-finite construction. Lee (1975) studied non-finite relative clauses on the basis of verbs or adjectives retained in the surface structure. Four types of non-finite relative clauses were examined: (i) to-infinitive relative, (ii) participial -ing relative, (iii) participial -ed/-en relative and (iv) verbless relative. The data from Lee's study reveal that there were 29 occurrences of infinitival relatives, 72 of participial -ing relatives, 168 of participial -ed/-en relatives and 30 occurrences of verbless relatives in the corpus (see Table 11). As participial -ed/-en relatives and participial -ing relatives were more frequently used than the others, they were selected for investigation in the present study.

Table 11

Relative Constructions: Non-finite (Restrictive)

to-infinitive	-ing	-ed/-en	verbless	Total
29	72	168	30	299

(Lee, 1975, p.168)

2. Restrictive clauses of finite construction. In studying the restrictive clauses of finite construction, Lee (1975) examined the frequency of occurrences of the relative elements -- that, which, who(m), whose, where, when and why and their functions (see Table 12). The occurrence of that as an adjunct is rare (only 2 occurrences in Lee's corpus), whereas that as an object occurs to a greater extent into 17 occurrences while that as a subject occurs frequently (69 occurrences). The relative element, which, occurs most frequently with subject function (64 occurrences in Lee's corpus). It is also fairly common with prepositional complement function (43 occurrences) but rare with object complement function (5 occurrences). Zero-relative functions mainly as an object complement (26 occurrences). There is only one occurrence of zero-relative as an adjunct. Relative elements where, when, why, which function as an adjunct were reported to occur infrequently (where (9 occurrences); why (1), and when (3)).

Table 12

Relative Constructions: Finite (Restrictive)

Rel.elements functions	that	which	who/whom	whose	zero			
					rel.pron.	where	why	when
subject	69	64	3	10	0	0	0	0
complement	17	5	0	4	26	0	0	0
adjunct	2	0	0	0	1	9	1	3
complement to preposition	0	43	3	0	0	0	1	0
Total	88	112	6	14	27	9	2	3

(Lee, 1975, pp.157-8)

The relative pronouns that (88 occurrences) and which (112 occurrences) are more frequently used than the other relative pronouns. Accordingly, they were included in the present study. The functions of these relative pronouns -- that and which, were also considered. It was decided to select for investigation the relative pronoun that, functioning as a subject, because

it occurs most frequently . (69 occurrences) when compared with the other functions. The relative pronoun which, functioning as a subject (64 occurrences) and as a complement to preposition (43 occurrences) was included in the present study, for it is more frequently used than the other functions.

Accordingly, the following five English grammatical structures of relativization became subject to investigation in the present study:

1. Non-finite (restrictive) participial -ed/-en relative construction

Example: "Calculate the total shear force supported by the hinge at A for a load of $W = 50,000$ lb in the position shown."

(Lee, 1975, p.164)

(Here, the relative clauses "supported by the hinge at A" and "shown" are reduced from "force which is supported by the hinge at A" and "in the position which is shown." Both relative clauses qualify their antecedent nouns "force" and "position" respectively.)

2. Non-finite (restrictive) participial -ing relative construction

Example: "Intramolecular F-C acylation resulting in the closure of five- or six-membered rings occurs in dilute solution in preference to intermolecular reaction."

(Lee, 1975, p.163)

(Here, the relative clause "resulting in the closure of five- or six-membered rings" is reduced from "acylation which results in the closure of five- or six-membered rings").

3. Finite (restrictive) relative construction with the relative element that as a subject

Example: "Rectifiers are electrical components that have the property of passing an electric current in one direction much more easily than in the other."

(Lee, 1975, p.152)

(In this sentence, that replaces the deleted noun phrase "electrical components" and takes its

function which is the subject of the constituent sentence.)

4. Finite (restrictive) relative construction with the relative element which as a subject

Example: "The component of the resultant along the surface is the friction force which is always in the direction to oppose the motion of the wedge."

(Lee, 1975, p.153)

(Here, the constituent sentence before embedding is "the friction force is always in the direction to oppose the motion of the wedge." The relative element which takes the function of the subject (the friction force) and defines the noun phrase.)

5. Finite (restrictive) relative construction with the relative element which functioning as a complement to a preposition

Example: "...the point determined by the process is independent of the order in which the points $A_1 A_2 \dots A_n$ are joined."

(Lee, 1975, p.153)

(The constituent sentence before embedding is "the points $A_1 A_2 \dots A_n$ are joined in the order." Which replaces the deleted noun phrase "order" and takes the function as complement to the preposition in.)

Complement structures in scientific English

A complement is the obligatory element that follows the main verb. This element may be a word, a phrase, or a clause (Lee, 1975, p.117). Following the criteria set forth by Chomsky (1970), Hudson (1971), Kiparsky and Kiparsky (1970) and Rosenbaum (1967), Lee examined the syntax and function of complement structures in scientific English under three separate sections:

- (i) Finite complements as (a) subject, (b) object;
- (ii) Non-finite complements as (a) subject, (b) object occurring with three classes of verbs ("persuade" "expect" and "neutral");

(iii) Gerundive complements after prepositions.

Of the complement structures in the corpus, Lee (1975) found that there were 281 occurrences of finite complements, 273 occurrences of non-finite complements and 171 of gerundive complements. The data from Lee's study revealed the relative frequency of occurrence of the various types of complement structures (see Table 13).

Table 13

Complementation (725)

Finite	Non-finite	Preposition-governed
281	273	171

(Lee, 1975, p.127, 134, 136)

1. Finite complements. Finite complements occur either as subject or object of the main verb of the sentence. Lee (1975) found that object complements were commoner than subject complements. Of the 281 occurrences of finite complement structures in the corpus, 243 were object complements whereas only 38 were subject complements. The finite object and subject complements were also examined by Lee (1975) to see whether they were declarative or non-declarative in form. The data from Lee's study revealed that the finite object complements which were declarative in form, occurred more frequently than those which were non-declarative (217 occurrences to 26). Accordingly, the finite object complements which were declarative in form were included in the present study. The finite subject complements which were declarative were also found to occur more frequently than those which were non-declarative (35 occurrences to 3 of those which were non-declarative). Therefore the finite subject complements which were declarative were selected for the study (see Table 14).

Table 14

Finite Complements

Object		Subject	
declarative	non-declarative	declarative	non-declarative
217	26	35	3

(Lee, 1975, p.127)

2. Non-finite complements. Lee (1975) examined non-finite complements by distinguishing between those complement structures which occur with the main verbs of the "expect" class, and those which occur with the main verbs of the "persuade" class. The complements were also examined in terms of whether the noun following the main verb has been retained or deleted from the surface structure. In a sentence like "I expected to go out", the subject noun phrase of the embedded sentence "I go out" is identical with the subject noun phrase of the main sentence "I expected", so it is deleted. However, in a sentence like "I expected Jim to go out", the subject noun phrase of the embedded sentence "Jim goes out" is not identical with the subject noun phrase of the main sentence "I expected", so it is retained on the surface structure.

Like the finite complements, non-finite complements may function either as the subject or the object of the main clause. It was found in Lee's study that object complements occurred more frequently than subject complements (211 occurrences of object complements as compared with 59 occurrences of subject complements) (Lee, 1975, p.134). Accordingly, the object complements were selected for the present study.

Object complements may take either a to-infinitive phrase or a participial phrase. Lee found in his study that complements with participial phrases were rare compared to the complements with to-infinitive phrases (see Table 15).

Table 15

Non-finite complements

Object complements with to-infinitive phrases	Object complements with participial phrases
211	3

(Lee, 1975, p.134)

As object complements with to-infinitive phrases are more frequently used than those with participial phrases, they were selected for an investigation in the present study.

To-infinitive complements were further examined by Lee (1975) according to eight different types of structures under which they may occur. Lee (1975) discussed these eight different types of structures on the following basis:

- (i) whether the subject noun phrase of a main clause and the subject noun phrase of an embedded clause are identical or different from each other,
- (ii) whether the subject noun phrase of the main clause is deleted from the surface structure,
- (iii) whether the subject noun phrase of the embedded clause is retained or is deleted from the surface structure,
- (iv) whether the to-infinitive object complement occurs after a verb -to be,
- (v) whether the infinitive performs an action on the object noun,
- (vi) whether the matrix structure involves the imperative form let.

Lee (1975) found the to-infinitive complements under Type 2 and 5 structures occur more frequently than the other types (see Table 16). The to-infinitive complement under Type 2 structure is identifiable as follows. The subject noun phrase of the embedded clause is different from that of the main clause. It is retained on the surface structure and

performs an action of the object noun. In the structure of Type 5, the subject noun phrase of the embedded clause is identical with that of the main clause. The subject noun phrase of the embedded clause is deleted from the surface structure. There is an object noun after the to-infinitive. Both types were included in the present study because of their frequency of occurrence in the Lee study. Examples follow.

Table 16

Object Complements with To-infinitive Phrases

Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8
14	62	19	9	45	21	7	34

(Lee, 1975, p.134)

Example (i): The to-infinitive complement (Type 2)

"A given functional group was thought to exhibit essentially the same chemical behavior regardless of its immediate structural environment."

(Lee, 1975, p.130)

(Here, the implied human agent of the main verb in the passive construction "was thought" has been deleted. The subject noun phrase of the embedded clause (functional group) is not identical to the subject noun phrase of the main clause "we", thus it has been retained on the surface structure. It is a functional group which exhibits the same chemical behavior.)

Example (ii): The to-infinitive complement (Type 5)

"... the increased conductivity caused by a rise in temperature tends to swamp the impurity conductivity."

(Lee, 1975, p.130)

(In the above sentence, the subject noun phrase of the embedded clause "the increased conductivity swamps the impurity conductivity" is identical with the subject noun phrase of the main clause "the increased conductivity tends ...", thus it is deleted from the surface structure. The verb infinitive "to swamp" is transitive, and allows an object noun after it.)

3. Preposition-governed complements. Table 17 presents the data from Lee's corpus on the frequency of occurrences of the prepositions used in scientific English. The participial -ing complements following a preposition were found to occur frequently in scientific English (171 occurrences). The prepositions which were used in Lee's corpus included by, of, in, on/upon, for, before, after, with and from.

Table 17

Preposition-governed Complements

by	of	in	on	for	others	Total
51	30	24	21	20	26	171

(Lee, 1975, p.136)

On the basis of the above data, the preposition by which occurred most frequently in the preposition-governed complements in Lee's corpus, was selected for the present study.

The following five English grammatical structures of "complementation" thus became the ones to be used in the present study:

1. Finite object complement which is declarative in form

Example (i): "As before, if x denotes the displacement of the particle, and we neglect x^2 and a^2 , we can show that the tension T remains constant."

(Lee, 1975, p.121)

(In this sentence, the finite construction functions as an object to the declarative clause with the verb "show". Here, "it" has been deleted from the surface structure.)

Example (ii): "It should be recognised that ... the terms in $(\Delta x)^2$ and $(\Delta x)^3$ drop out."

(Lee, 1975, p.121)

(In this sentence, the finite construction functions as an object to the declarative clause with the verb "recognise". However, the declarative clause is passive. With the passive construction, it has been retained on the surface structure. The sentence (It should be recognised that...) is actually a passive transformation of (We should recognise it that ...:)

2. Finite subject complement which is declarative in form

Example (i): "That a resonance effect is responsible for the remainder of the difference is evident from the following arguments."

(Lee, 1975, p.124)

(In this sentence, the finite complement functions as a subject to the declarative clause with the verb "is". However, the abstract noun has been deleted from the subject complement.)

Example (ii): "The fact that the back current is small and independent of the backward potential is clear."

(Lee, 1975, p.125)

(In the above sentence, the finite complement functions as a subject to the declarative clause with the verb "is". The abstract noun "fact" is retained in the surface structure.)

3. To-infinitive complement functioning as an object (Type 2)

Example: "A given functional group was thought to exhibit essentially the same chemical behavior regardless of its immediate structural environment."

(Lee, 1975, p.130)

(The explanation for this structure has been given earlier (see page 9)).

4. To-infinitive complement functioning as an object (Type 5)

Example: "... the increased conductivity caused by a rise in temperature tends to swamp the impurity conductivity."

(Lee, 1975, p.130)

(The explanation for this structure has been given earlier (see page 9)).

5. Participial -ing object complement following the preposition "by"

Example: "We can now transform the observation from 0^1 into the observation from 0 by eliminating the primed quantities from Eq. (5-17)."

(Lee, 1975, p.137)

(In the above sentence, "by" is used to introduce the -ing object complement. It has instrumental function and follows an active matrix clause.)

Comparative constructions in scientific English

Lee (1975) studied comparisons according to the form of the comparative element and the expansion it took. His classification of comparative structures was based on the works of Smith (1961) and Pilch (1965) (traditional-structural grammar); Hale (1970), Lees (1961), and Stanley (1969) (transformational grammar) and Huddleston (1967) (systemic grammar). Three areas of comparative structures were formulated in Lee's study as follows:

- (i) Comparison of inequality - with more, less, or -er appearing in the matrix clause and than (or than deleted) appearing in the constituent clause;
- (ii) Comparison of equality - with as or so appearing in the matrix clause and a second as (or as deleted) in the constituent clause; and
- (iii) Comparison of similarities or differences - with the same, similar, different, rather, or other, appearing in the matrix clause and the respective expansion as, to, from, than (each of these may be deleted) appearing in the constituent clause.

Table 18 presents the data on the frequency of occurrence of the comparative structures of inequality, of equality and of similarities or differences, in Lee's study.

Table 18

Comparative Structures (518)

Similarities/ Differences	Inequality	Equality	Others
216	153	90	59

(Lee, 1975, pp.182, 187, 189, 192, 194-5)

1. Comparisons of similarities or differences. Comparative elements such, same and similar mark comparisons of similarities; those of different, other and rather mark comparisons of differences. Same, similar, different and other have adjectival function, but such and rather normally do not. Lee (1975) explained the function of such and rather as follows:

Such often functions as submodifier in the nominal group as in such beautiful trees and such a result, though it may occur in the position of an adjective as in four such reasons. With rather, the normal

function is adjunct of degree, or in cases like rather than as a single unanalysable unit.

(p.187)

Table 19 shows the data from Lee's study on the frequency of occurrence of comparative elements and their functions. For comparisons of similarities, the comparative element same occurred more frequently than the comparative elements such and similar (58 occurrences of the comparative element same as compared with 54 occurrences of the comparative element such and with 14 occurrences of the comparative element similar). Accordingly, the comparative element same was selected for the present study. Among comparisons of differences, the comparative element other occurred more frequently than the comparative elements different and rather (51 occurrences of other as compared with 35 occurrences of different and with 4 occurrences of rather). Therefore the comparative element other was included in the present study.

Table 19

Comparisons of similarities and Differences

Comparisons of similarities			Comparison of differences		
same	such	similar	different	rather	other
58	54	14	35	4	51

(Lee, 1975, p.192, 194, 196)

Lee also examined whether the comparative elements same and other have either anaphoric, cataphoric or reciprocal references. These three types of reference were explained as follows:

If the comparative expansion element appears on the surface structure, the comparison is cataphoric, that is, the item points "forward" across the boundary of a sentence. If it is deleted, the comparison is either anaphoric, that is, the item refers "backward" to the preceding sentence or sentences, or reciprocal, that is, the item refers to the immediate situation.

(Lee, 1975, p.176)

Of 58 occurrences of the comparative element same, Lee found in his corpus that same used as reciprocal reference occurred more frequently than same used as an anaphoric or cataphoric reference (29 occurrences of reciprocal reference to 16 of anaphoric and 13 of cataphoric reference). Accordingly, the comparative element same used with reciprocal reference was selected for investigation in the present study. For the comparative element other, Lee found that of 51 occurrences, 38 had anaphoric reference and only 13 had reciprocal reference. The comparative element other was more frequently used with anaphoric reference, therefore it was included in the study (see Table 20).

Table 20

Functions of the Comparative Elements same and other

<u>Comparison of similarity</u>			<u>Comparison of difference</u>		
same			other		
Anaphoric	Cataphoric	Reciprocal	Anaphoric	Cataphoric	Reciprocal
16	13	29	38	0	13

(Lee, 1975, p.189, 194)

The following two textual sentences from Lee's study exemplify the comparative structure with same used reciprocally and the comparative structure with other used with anaphoric reference:

- (i) "But the final momentum must be the same as the initial momentum ..."

(Lee, 1975, p.188)

(Here, the comparison is between the final momentum and the initial momentum in terms of the similarity of result. Cataphoric reference is marked by the use of the same as.)

- (ii) "Because of the particular orientation of groups required, m-nitrophenal could not readily be prepared by other route."

(Lee, 1975, p.193)

(In this sentence, the detailed expansion with than would be "other route than the one discussed earlier." Anaphoric reference has to be applied to get the exact meaning of the sentence.)

2. Comparisons of inequality: Comparative structures of inequality are marked by more, less, -er. These structures may occur with either the presence or absence of than.

(i) Comparisons of inequality with the absence of than.

Comparative structure may be used either as an anaphoric reference or as an homophoric reference. Lee found that comparisons of inequality used anaphorically occurred more frequently than those used as a homophoric reference (see Table 21). Accordingly, the comparison of inequality used anaphorically was included in the present study.

Example: "The saturation electron current, IBA, has the same magnitude as before, but now the more energetic electrons in A can surmount the function barrier far more easily ..."

(Lee, 1975, p.178)

(In this sentence, "the more energetic electrons in A" implies that there are other energetic electrons but these latter are not as energetic as the electrons being said. The surmounting of the junction barrier is easier with the more energetic electrons than with the others.)

(ii) Comparisons of inequality with the presence of than.

This type of comparative structure is used as a cataphoric reference. Lee discussed the cataphoric comparative as follows:

The pairs of comparative clauses appearing in the surface structure have parallel underlying structures; the cataphoric more, less, -er not only presupposes the existence of the expansion but also looks "forward" across the boundary of a sentence for the appearance of the expansion.

(Lee, 1975, p.180)

The cataphoric comparative was also examined by Lee in terms of explicit comparison, implicit free comparison or implicit bound comparison. A distinction between explicit and implicit comparison was described by Huddleston (1967) as follows:

In the former, the comparative expansion consists of than plus a nominal group; in the latter, than introduces a clause, though this may be realized in surface structure by a single nominal group (p.92).

Free and bound comparison were also distinguished by Huddleston (1971) who stated that:

In a bound comparison all the material in the underlying than-clause is either new and contrastive with respect to the matrix or else given in the matrix: the given material may be deleted, replaced by a pro-form or repeated with weak stress the free type are single variable comparisons where the variable is the whole clause, not individual phrases (or words) within it (pp.271-272).

Lee (1975) found that out of a total of 71 comparisons of inequality with the presence of than, those of the implicit bound (50 occurrences) occurred most frequently (see Table 21). The implicit bound comparison, therefore, was included in the present study.

Example: "For transmitting power or motion the square thread is more efficient than the V-thread."

(Lee, 1975, p.181)

(Implicit comparison as in the above sentence involves only one variable in comparison, that is, efficiency. The subject variable is "the square thread" and this is compared with the "V-thread" in terms of an "implicit" standard - efficiency.)

Table 21

Comparisons of Inequality: more, less, -er

With the absence of <u>than</u>				
Anaphoric	Homophoric	Cataphoric	Total	
56	24	2	82	
With the presence of <u>than</u>				
Explicit	Implicit free	Implicit bound	Others	Total
7	1	50	13	71

(Lee, 1975, p.182)

3. Comparisons of equality. Comparisons of equality are marked by the elements as and so. Lee (1975) examined comparisons of equality according to five main categories, (i) with anaphoric reference, (ii) with cataphoric reference, (iii) with relative clause characteristics, (iv) with manner clause characteristics, and (v) with compound conjunction characteristics. The data from Lee's study as shown in Table 22 revealed that anaphoric reference and cataphoric reference of comparison of equality did not play an important part in his corpus (9 and 3 occurrences respectively). Comparative structures with as showing relative-like characteristics were frequently used in the corpus (52 occurrences). Manner as clauses were not common in the corpus (8 occurrences). There were 18 occurrences of as with compound conjunction characteristics. As the comparative structures with as showing relative-like characteristics were the most frequently used, they were included in the present study.

Example: (the comparative structure with as showing relative-like characteristics):

"Vectors are compounded by geometrical addition as indicated in formula (1) and (2) of the last article."

(Lee, 1975, p.184)

(In the above sentence, "as indicated in formula ..." behaves like the non-restrictive relative clause "which is indicated in formula ...". The comparative clause with as adds supplementary information to the matrix, without qualifying any preceding item.)

Table 22

Comparisons of Equality: so/as

Anaphoric	Cataphoric	Relative-like	Manner	Compound Conjunction	Total
9	3	52	8	18	90

(Lee, 1975, p.187)

Thus, the following five English grammatical structures of "comparison" were included in the present study:

1. Comparison of similarity with the comparative element same used reciprocally

Example: "But the final momentum must be the same as the initial momentum ..."

(Lee, 1975, p.188)

2. Comparison of difference with the comparative element other used as an anaphoric reference

Example: "Because of the particular orientation of groups required, m-nitrophenal could not readily be prepared by other routes!"

(Lee, 1975, p.193)

3. Comparison of inequality used anaphorically with the absence of than.

Example: "The saturation electron current, IBA, has the same magnitude as before, but now the more energetic electrons in A can surmount the junction barrier far more easily ..."

(Lee, 1975, p.178)

4. Comparison of inequality involving the implicit bound comparison with the presence of than

Example: "For transmitting power or motion the square thread is more efficient than the V-thread."

(Lee, 1975, p.181)

5. Comparison of equality with as showing relative-like characteristics

Example: "Vectors are compounded by geometrical addition as indicated in formula (1) and (2) of the last article."

(Lee, 1975, p.184)

Construction of the Test Items

Selection of the target sentences

The primary aim of the test was to determine the comprehensibility levels of English complement, comparative and relative structures encountered by Thai science students in the reading of science textbooks. Therefore it was decided to select target sentences from basic science university textbooks set as required reading. The three science textbooks used were:

- (i) Weisz, P.B. The science of Biology. New York: McGraw-Hill Book Company, 1971.
- (ii) Alonso, M., and Finn, E.J. Physics. Addison-Wesley Publishing Company, Inc., 1972.
- (iii) Kice, J.L. and Marvell, E.N. Modern principles of organic chemistry - an introduction. New York: Macmillan Publishing Co., Inc., 1974.

The following steps were taken in order to select the target sentences for the test. Firstly, sentences representing the particular types of English complex structures under investigation were randomly drawn from three science textbooks. Secondly, each selected sentence was examined to see if it was a self-contained meaningful sentence and if it contained enough information so that it could be tested in a multiple-choice format. Thirdly, the selected sentences were reviewed by three science lecturers. The purpose was for the subject matter experts to check the content, to see whether each sentence would be comprehended just by reading it, that is, that the meaning of the sentence did not totally depend on the context which preceded it. Finally, these sentences were reviewed by two English language specialists. The purpose was for them to check that the sentences in fact represented a structure of the type supposedly being tested.

In order to determine the number of items used for measuring the comprehensibility level of each grammatical structure for Thai science students, certain practical considerations were taken into account. First of all, chance success due to the use of a multiple-choice format had to be guarded against. This was done by including in the test a sufficient number of items based on the same linguistic element (Clark, 1972a, 1972b). Blatchford (1971) suggests on the basis of the result of his experimental study, that tests consisting of two items per language feature would be enough to eliminate the chance success factor. At the same time, the total length of the test had to be limited so that fatigue would not influence the result. The present study therefore included three items to measure each linguistic feature. The three items thus permitted a sentence to be randomly selected from each of the three texts -- one in physics, one in biology, one in chemistry. In this way, 45 English sentences, representing 15 English grammatical structures (five complements, five comparatives and five relatives) were obtained.

Vocabulary control

In order to be sure that student errors were due to a lack of understanding of selected English structures and not a lack of knowledge of vocabulary used in the target sentences or in the test items, a list of words used in the target sentences with their meaning translated into the Thai language was provided along with the test booklet. The students were encouraged to use the vocabulary list whenever they wished.

It was decided to control knowledge of vocabulary in this way (instead of constructing target sentences using the familiar words listed in West's A General Service List of English Words (1953)) because the primary aim of the present study was to investigate the comprehensibility levels of English structures which actually occur in the kind of English which science students had to read.

The list of words with their meaning in Thai was first prepared by the author of the present study. However, in order to check the accuracy of the translation of science vocabulary, the list was reviewed by a Thai scientist whose English language proficiency was very good.

Construction of the multiple-choice items

The purpose of the test was to determine the comprehensibility levels of 15 selected English grammatical structures used in scientific English. These comprehensibility levels were to be determined on the basis of how well or how poorly the subjects of the present study could understand the structures under investigation. Therefore, an effort was made to produce a meaning oriented test rather than a usage oriented test. This was achieved by making all of the possible choices as well as the distractors grammatically correct.

In the test, each item consisted of (i) a target sentence where each structure under investigation could be found, (ii) either a stem question or incomplete statement to which a reasonably adequate answer or completion could be given and for which plausible wrong answers could be found and (iii) four choices from which only one answer was correct.

In order to make all four choices plausible and attractive to students who might lack understanding of each particular structure tested in the item, construction was based on the following general criteria.

1. All choices should be parallel in grammatical structure.

Example: Item 10

What do we know about the wavelengths of electromagnetic waves in cosmic radiation and the wavelengths of electromagnetic waves in the other kinds of radiation?

- (a) They are the same.
- * (b) They are different.
- (c) They are equally short.
- (d) They are equally long.

(Here, all choices follow the same sentence pattern:
N + V (to be) + Adj)

2. The choices in each item should be approximately the same length or be paired by length.

Example: Item 2

What determines the strength of the electromagnetic interaction of one particle with other particles?

- * (a) Charge of each particle
- (b) The strength of each particle
- (c) The strength of other particle
- (d) Characteristics of each particle

3. In each item, it should not be possible to answer from general knowledge, without reference to the sentence.

4. All four choices should include the lexical units found from the target sentences. Changes in word order, inflectional endings, derivational affixes, and/or function words were used to indicate different meanings among the four choices.

Example: Item 6

Cenozoic climates played a major role in plant evolution, as noted earlier.

(Bio. p.567)

According to the sentence, what has been noted earlier?

- (a) Cenozoic climates
- (b) Plant evolution in cenozoic climates
- * (c) Cenozoic climates' influence on plant evolution
- (d) Plants in cenozoic climates

5. The plausible distractors should be constructed by focusing on the weaknesses which might occur as a result of not understanding each particular structure under investigation.

Example (i): In a non-finite (-ed/-en) relative construction, it is important to recognize the embedded sentence and be able to identify the subject noun phrase of the embedded sentence. Therefore the distractors were constructed to find out whether the students could identify the subject noun phrase of the matrix sentence and the subject noun phrase of the embedded sentence.

Item 17: Each carbon of the C=C is converted to a C=O, and any hydrogen attached to these particular carbons is converted to an -OH group.

(Chem. p.40)

What is converted to an -OH group?

- (a) Each carbon of the C=C
- (b) Any hydrogen
- * (c) The hydrogen of $\begin{array}{c} \text{-C=C=} \\ | \\ \text{H} \end{array}$
- (d) These particular carbons

Example (ii): In a subject complement construction, it is important to recognize the embedded sentence which functions as a subject noun phrase of the matrix sentence.

Item 5: The fact that an electric current produces a magnetic field suggests that a single moving charge must also produce a magnetic field.

(Physics p.379)

What suggests that a single moving charge must also produce a magnetic field?

- (a) A magnetic field
- (b) An electric current
- * (c) An electric current produces a magnetic field
- (d) The fact that there is an electric current

Example (iii): In a comparative structure of inequality, it is important to recognize both the comparative element and what is being compared.

Item 34: The energy levels of an atom with several electrons are much more complex than those of atoms with one electron.

(Physics p.602)

According to the above sentence, what are the most complex?

- (a) The energy levels of atoms with one electron
- (b) Atoms with one electron
- (c) Atoms with several electrons
- * (d) The energy levels of an atom with several electrons

The original 45 items representing 15 English grammatical structures were first reviewed by the same three science lecturers. They were asked to check the accuracy of the science content in the questions, in the possible answers and in the distractors. Their comments were taken into account in the first revision of the test items. These revised items were then reviewed by a specialist in the field of teaching English as a foreign language. The purpose was to check the accuracy of the use of language as well as the quality of the test items which were aimed at testing particular language features. The test items were revised and were tried out on a group of science students at Chiangmai University.

Pilot Testing

The purpose of the pilot testing was to undertake an item analysis in order to improve the quality of the test and to discover any weaknesses in the directions given to examiners and examinees.

Test sample

The sample used in the pilot testing consisted of 124 first year science students from Chiangmai University. These students were chosen because they had English language backgrounds similar to the science students at Khon Kaen University (the proposed subjects of the present

study) - and because they were accessible and cooperative. The 124 students were from the faculties of Pharmacy, Technical medicine, Science, Nursing and Education majoring in science. They were all paid volunteers.

Test administration

The test of 45 items measuring comprehension of 15 English grammatical structures was administered to a group of 124 first year science students in the morning session on June 30, 1979. Before the test was taken, three lecturers to be used as proctors met with the author so that the instructions given to the students were made clear. The students were placed into two separate rooms, with two proctors in one and the author and one proctor in another. Each student was given a test booklet with an answer sheet, and the vocabulary list with the meanings in Thai. There was no time limit set for the students to complete the test. They were encouraged to do the test the best way they could. They were told to look up unfamiliar words in the vocabulary list anytime they wished, and were told that there was no penalty for doing so. The reason for not setting a time limit was twofold. Firstly, it was to provide the researcher with an idea of the amount of time taken to complete the whole test in the actual testing. Secondly, it was to make sure that all items were completed by all students so that enough information was obtained to improve the quality of the test.

Scoring procedure

The students' answers to the test were hand scored. A punched key, which was the regular answer sheet with the correct responses punched out, was prepared in advance. Each correct answer was given one mark.

Results

The results of the test administered to the 124 science students are presented in Table 23.

Table 23

English Grammatical Structures Test: Basic Statistics

Test Variable	N	Mean	Median	Range	SD
English grammatical structures Test (n = 45 items)	124	22.66	21.7	17-40	6.38

The Kuder-Richardson 20 reliability was .79.

To improve the quality of the test, a careful examination was made of the test items of which the discrimination indices were less than .40. The data obtained from the item analysis were used as guidelines to revise the possible answers and the distractors. After the revision was made, it was reviewed by the same three science lecturers and then by the same language specialist. A revised test of 45 items was then made ready to be administered in the main testing at Khon Kaen University.

The test itself was composed of 45 test items, measuring five English complements, five comparatives and five relative structures (three items for each structure). A sample item for each structure measured is illustrated in a list of sample items below. The complete test is to be found in Appendix C.

Sample Items Measuring English Complex Structures

Relativization

1. Non-finite (restrictive) participial -ed/-en relative construction

Item 17: Each carbon of the C=C is converted to a C=O, and any hydrogen attached to these particular carbons is converted to an -OH group.

(Chem. p.40)

What is converted to an -OH group?

- (a) Each carbon of the C=C
- (b) Any hydrogen
- * (c) The hydrogen of $\begin{array}{c} \text{-C=C-} \\ | \\ \text{H} \end{array}$
- (d) These particular carbons

2. Non-finite (restrictive) participial -ing relative construction

Item 4: Biological competition between two different types occupying the same territory often has led to the extinction of one.

(Bio. p.781)

According to the sentence,

- (a) Biological competition occupies the same territory.
- (b) Two different types often lead to the extinction of one.
- * (c) Biological competition often leads to the extinction of one.
- (d) Biological competition between two different types occupies the same territory.

3. Finite (restrictive) relative construction with the relative element that as a subject

Item 2: Charge is another coefficient, characteristic of each particle, that determines the strength of its electromagnetic interaction with other particles.

(Physics p.19)

What determines the strength of the electromagnetic interaction of one particle with other particles?

- * (a) Charge of each particle
- (b) The strength of each particle
- (c) The strength of other particle
- (d) Characteristic of each particle

4. Finite (restrictive) relative construction with the relative element which functioning as a subject

Item 30: In the gut of termites live flagellate protozoa which secrete an enzyme capable of digesting the cellulose of wood.

(Bio. p.105)

Flagellate protozoa _____

- (a) are secreted by an enzyme.
- (b) secrete the cellulose of wood.
- * (c) produce an enzyme.
- (d) are an enzyme capable of digesting the cellulose of wood.

5. Finite (restrictive) relative construction with the relative element which functioning as a complement to a preposition

Item 40: The various orbitals in which the electrons of an isolated atom may be found are called atomic orbitals.

(Chem. p.10)

According to the sentence,

- (a) The electrons of an isolated atom are called atomic orbitals.
- (b) An isolated atom may be found in atomic orbitals.
- (c) The various orbitals of an isolated atom may be found.
- * (d) Orbitals of electrons of an isolated atom are called atomic orbitals.

Complementation

6. Finite object complement which is declarative in form

Item 24: The minus sign indicates that the net flow (mass transport) is in the direction in which n (the concentration of the substance) decreases.

(Physics p.284)

What does the minus sign indicate?

- (a) The area of greater concentration
- * (b) The direction of the net flow
- (c) The decrease of the net flow
- (d) The decrease of the concentration of the substance

7. Finite subject complement which is declarative in form

Item 5: The fact that an electric current produces a magnetic field suggests that a single moving charge must also produce a magnetic field.

(Physics p.379)

What suggests that a single moving charge must also produce a magnetic field?

- (a) A magnetic field
- (b) An electric current
- * (c) An electric current produces a magnetic field
- (d) The fact that there is an electric current

8. To-infinitive complement functioning as an object (Type 2)

Item 18: An embryonic ovary of a human female is estimated to contain some 400,000 primordial germ cells.

(Bio. p.502)

Which of the following sentences best describes the above sentence?

- (a) The human female contains some 400,000 primordial germ cells.
- * (b) We guess that the embryonic ovary contains some 400,000 primordial germ cells.
- (c) The embryonic ovary is contained in some 400,000 primordial germ cells.
- (d) We estimate the embryonic ovary in order to let it contain some 400,000 primordial germ cells.

9. To-infinitive complement functioning as an object (Type 5)

Item 27: The masses of the fundamental particles do not seem to show any kind of regularity.

(Physics p.518)

About what are we uncertain?

- (a) The various kinds of the fundamental particles
- (b) The masses of the fundamental particles
- (c) Any kind of regularity
- * (d) The regularity of the masses of the fundamental particles

10. Participial -ing object complement following the preposition by

Item 1: One can synthesize methyl t-butyl ether from t-butyl chloride by allowing the halide to react with methanol.

(Chem. p.229)

Which of the following sentences best describes the above sentence?

- (a) Methyl t-butyl ether allows t-butyl chloride to react with methanol.
- (b) T-butyl chloride allows methyl t-butyl ether to react with methanol.
- (c) One can synthesize methyl t-butyl ether from t-butyl chloride and then allow the halide to react with methanol.
- *(d) One can synthesize methyl t-butyl ether from t-butyl chloride when one allows the halide to react with methanol.

Comparison11. Comparison of similarity with the comparative element same used reciprocally

Item 22: The two spatial arrangements represent two different configurational isomers of the same molecular formula.

(Chem. p.133)

Which are the same?

- (a) The molecular formulas of two spatial arrangements
- (b) Two different configurational isomers
- (c) Two spatial arrangements and two different configurational isomers
- *(d) The molecular formulas of two different configurational isomers

12. Comparison of difference with the comparative element other
used with anaphoric reference

Item 45: There are a number of other reactions of acid derivatives that also involve initial nucleophilic attack on the carbonyl group.

(Chem. p.405)

What do we know about the reactions of acid derivatives?

- * (a) Many more of the reactions of acid derivatives haven't been mentioned yet.
- (b) There are only reactions of acid derivatives that involve initial nucleophilic attack on the carbonyl group.
- (c) A number of acid derivatives have been mentioned before.
- (d) There are a number of reactions besides the reactions of acid derivatives.

13. Comparison of inequality used anaphorically with the absence of than

Item 10: In cosmic radiation there are electromagnetic waves of even shorter wavelengths.

(Physics p.579)

What do we know about the wavelengths of electromagnetic waves in cosmic radiation and the wavelengths of electromagnetic waves in the other kinds of radiation?

- (a) They are the same.
- * (b) They are different.
- (c) They are equally short.
- (d) They are equally long.

14. Comparison of inequality involving the implicit bound comparison with the presence of than

Item 20: Most materials in the physical world actually require activation energies far greater than those energies provided by ordinary temperatures.

(Bio. p.40)

According to the above sentence, what play the most important role on most materials in the physical world?

- (a) Energies in the physical world
- (b) Most materials in the physical world
- (c) Energies provided by ordinary temperatures
- * (d) Activation energies

15. Comparison of equality with as showing relative-like characteristics

Item 6: Cenozoic climates played a major role in plant evolution, as noted earlier.

(Bio. p.567)

According to the sentence, what has been noted earlier?

- (a) Cenozoic climates
- (b) Plant evolution in cenozoic climates
- * (c) Cenozoic climates' influence on plant evolution
- (d) Plants in cenozoic climates

In organizing the test, all test items were randomly ordered so that no priority was given to any particular structure under investigation. The position of the correct answer in each item was randomly assigned (see Appendix C). The directions for administering the test were developed as a result of administering the initial form to a group of 124 science students (see Appendix D). A key for scoring the test was prepared (see Appendix E).

Construction of the English-Thai Translation Test
of English Grammatical Structures

An English-Thai Translation Test of English Grammatical Structures was developed for use as a criterion test on which a test of English Grammatical Structures applying a multiple-choice format could be based. In this way, the Multiple-choice Test of English Grammatical Structures could be tested for its concurrent validity as a measure of comprehension of English structures.

Selection of 15 English Grammatical Structures

The 15 English grammatical structures selected for this test were the same as those in the Multiple-choice Test of English Grammatical Structures. The procedure for the selection of these structures was given in full detail elsewhere (see p. 104).

Selection of 45 Target Sentences

The selected 45 English sentences representing 15 complex structures were the same as those in the Multiple-choice Test of English Grammatical Structures. The procedure for the selection of the sentences was given in full detail elsewhere (see pp. 124-125).

Pilot Testing

It was obvious when the translation method was used as a testing device that the marking would be inevitably rather subjective (Lado, 1961). An effort was therefore made to overcome this problem as much as possible. This was done by conducting a pilot testing from which accurate information on the translation of English sentences into Thai could be obtained. On the basis of the data collected it was hoped that the scoring method could be made more objective.

Test sample

Ten science students from Mahidol University participated in this pilot testing. They were all paid volunteers.

Test administration

The English-Thai Translation Test of English Grammatical Structures was administered to a group of 10 science students on February 22, 1979.

Each student was given a booklet which contained 45 English sentences. The blank spaces were provided below each of these sentences. The students were instructed to translate the English sentences into Thai the best way they could and to write down their Thai translation on the space provided. Each student was also given a vocabulary list with Thai meaning. There was no time limit set for the students to complete the test. This was to ensure that all sentences were translated by every student.

Scoring procedure

The author first translated 45 sentences into Thai, then submitted this to three Thai science lecturers who independently evaluated it. The correct interpretation was made on the basis of their recommendations. A copy of 45 English sentences translated into Thai was then made. To mark the test, each sentence translated correctly according to the key was given one mark. However, the exact equivalence translation was not required.

In order to ensure the reliability of the scoring method, two scorers, including the author and a fourth year science student, were used. After the translation was marked, the result showed that there was an agreement between two scorers. Out of 450 items marked, only two items have shown disagreement between the two scorers.

As the main purpose for the pilot testing was to find out the best way to score the translation test, no attempt was made to obtain the basic statistics and its reliability.

Conclusions

Four tests were developed for the present study. They were:

- (i) A Cloze Reading Comprehension Test
- (ii) A Multiple-choice Reading Comprehension Test
- (iii) A Test of English Grammatical Structures
(applying the multiple-choice format)
- (iv) An English-Thai Translation Test of English Grammatical Structures

The first two tests were constructed to measure the ability of Thai science students to comprehend scientific English passages. They were to be used to distinguish good readers of scientific English from poor readers. The latter two tests were developed to measure the comprehensibility of fifteen selected English grammatical structures for Thai science students.

An attempt was made to develop good reliable tests. This was achieved by carefully selecting either sample passages or sample sentences to be used in the tests, by carefully constructing the test items and by conducting several pilot tests.

On the basis of the data collected from pilot tests, the tests were considered reliable and appropriate for use in the main study.

The next chapter will describe the administration of the four tests and the results.

CHAPTER 4

TEST ADMINISTRATION AND TEST RESULTS

The four tests described in the previous chapter were administered to 190 Thai science students as the "formal" subjects of the study, at Khon Kaen University, Thailand, on July 22, 26 and 30, 1979. Descriptions of the administration of the four tests and the tests' psychometric properties are given in the following sections.

Procedures

Time Arrangement

Time was one of the obstacles in collecting the data. The main reason was that students from different faculties had different lecture time schedules. The test programme required the subjects to sit each test for a period of approximately two hours. The opportunity for administering each test during lecture classes was rare. It was impossible when 190 students from five different faculties were required to take each test for two hours at the same time and on the same day. Accordingly, the author took the following steps to arrange the days for administering the four tests:

- (i) The decision was made to administer the tests either on weekends or in the late evenings of weekdays.
- (ii) The university calendar, the students' counsellor, the student president and the student leader from each faculty were consulted. The purpose was to select the days in which none of the subjects had any scheduled social activities.

Student Co-operation

In order to obtain the co-operation of the students, the researcher next approached the administrators, the lecturers and the students taking advantage of the experience obtained from the previous pilot testing.

The following steps were taken to obtain co-operation from the subjects:

- (i) With the co-operation of the lecturers, the author successively met the students from all faculties at the beginning of a lecture.
- (ii) At the meeting with the students, the author explained to them the objectives of the study, the importance of their co-operation, the tests to be taken, the days and the times set for the administration of the tests and the amount of money paid for participating in the study (see Appendix F for the talk).
- (iii) Those students who were absent from the classes on the day the author gave this talk were contacted by mail (see Appendix G for the letter used).
- (iv) The students' signatures indicating that they would willingly participate in the study were gathered.

Room Arrangement

As the time for administering the four tests was on odd days and at odd times, exam rooms and halls to accommodate 250 students were pre-arranged. The following steps were taken to ensure the access to the exam rooms:

- (i) Rooms or halls which were suitable for the supervision of 250 students at the same time and on the same day were ascertained. Three science halls in the faculty of science were chosen as the test rooms.
- (ii) Permission was obtained from the Dean of the faculty of Science to use the science halls on weekends and in the late evenings of weekdays.
- (iii) The lecturers who were directly in charge of the science building were contacted officially and personally.
- (iv) The author confirmed with the lecturers the date and the time the science halls would be used.

Cloze Test Administration

Test Booklet

As the nature of the Cloze Test requires a great deal of concentration on the part of the students, bias resulting from the order of presentation of any particular passage should be minimized. Test booklets, therefore, were prepared in three different forms. The only difference was in the order of presentation (see Figure 4 below).

Title of the passage	Order of presentation		
	Form 1	Form 2	Form 3
Parasitic Reproduction	1	3	2
Covalent Bonds	2	1	3
Molecular Diffusion	3	2	1

Figure 4. Alternative Forms: Cloze Test

Test Administration

The Cloze test (three reading passages plus 90 items) was administered to the 190 students in the first session, July 22, 1979 in three separate exam rooms. Two lecturers were asked to supervise 77 agriculture students in science hall 101. Another two lecturers supervised 85 medical and nursing students in science hall 102. The author and the other two lecturers supervised 88 science and education students in science hall 103.

The author met with the six lecturers an hour before the administration of the test. The instruction sheet which provided guidelines on how to administer the test was distributed to each lecturer (see Appendix H). The researcher explained the directions for administering the test and the lecturers were asked to follow the instructions strictly.

The test booklets were placed on the students' desks before they entered the test room. When they had taken their seats, the students were asked to take the answer sheet out of the back page of the test booklet, and write down their names and their Faculties on the space

provided. Then the lecturers explained to the students the purpose of the test repeating that to complete the test their co-operation was needed. Then the lecturers said the following words to the students (English translation):

Turn to the example page. Notice that three words are missing from the story "Our school". You are required to fill in these three blank spaces with the words which are appropriate to the context. You must fill in only one word for each blank. To complete the test, it is suggested you read the whole story first. The reason is for you to guess what the passage is about. Then try to fill in the blanks with the appropriate words. For example, read the story like this: "Boys/ girls go to our school. At/ we learn to read. We also learn how/ write." Then read the story again, this time you have to try to fill in the blank with the word which you think is the most appropriate to the context. Now, fill in the first blank (Here the lecturer pauses one moment for the students to fill in the first blank). Now let's check the correct answer. The appropriate word for the first blank is and. Boys and girls go to our school. Now complete the rest of the story (Here the lecturer pauses for one minute). The appropriate words for the second and the third blanks are school and to. Next, let's practise more on the story "The Countdown". This time fill in the blanks on the answer sheet.

After 3 minutes, the lecturer said the following words:

The appropriate answers for the story "The Countdown" are: seven, two, the, it, see.

Then the lecturer gave final instructions making sure that everybody understood. The students were instructed to fill in only one word for each blank, were encouraged to guess if they could not find the appropriate words. They were asked to write down their answers on the answer sheet provided.

The test took two hours and fifteen minutes to complete.

Example (ii): A plural noun was wrongly used for a singular noun.

"As a final illustration..." (correct)

"As a final examples ..." (wrong)

(Item 28 - Molecular Diffusion)

Example (iii): An adjective was wrongly used for an adverb.

"..we can smell it very quickly.." (correct)

"..we can smell it very quick.." (wrong)

(Item 4 - Molecular Diffusion)

Example (iv): A verb in its past simple tense was wrongly used for the verb in its present simple form.

"..molecules diffuse through the water.." (correct)

"..molecules diffused through the water.." (wrong)

(Item 12 - Molecular Diffusion)

Example (v): A verb in its present participle form was wrongly used for the verb in its past participle form.

"..a pair of outer-shell valence electrons are shared .." (correct)

"a pair of outer-shell valence electrons are sharing .." (wrong)

(Item 4 - Covalent Bonds)

2. Any blanks which contained two words were excluded even though the result may have been acceptable semantically. For example:

"this number must vary from place to place in order for diffusion to occur." (correct)

"this number must vary from place to place in order for diffusion to take place." (wrong)

(Item 30 - Molecular Diffusion)

Each exact replacement of a deleted word and each response that was contextually or semantically acceptable was given one mark. Incorrect spelling was not penalized as long as the word was recognizable.

Results

The results of the exact and acceptable word scoring procedures to the data collected from the 190 students are presented in Tables 24 and 25.

Table 24

Cloze Test (Exact Word Scoring): Basic Statistics

Test Variable	N	Mean	Median	Range	SD
Cloze Test (exact word scoring) (n = 90 items)	190	28.72	28.08	10-52	7.18

Table 25

Cloze Test (Acceptable Word Scoring): Basic Statistics

Test Variable	N	Mean	Median	Range	SD
Cloze Test (acceptable word scoring) (n = 90 items)	190	36.50	35.93	16-62	8.59

Reliability

Reliability coefficients were obtained by the Kuder-Richardson Formula 20 (Kuder & Richardson, 1937). This formula measures the internal consistency of the test, utilizing information on the proportion of subjects passing and failing each item and the standard deviation of the total scores (Gronlund, 1971). The Kuder-Richardson Formula 20 coefficients of the Cloze Test, in the present study, for the exact word scoring procedure and the acceptable word scoring procedure, were .78 and .82 respectively and indicate a substantially high level of internal consistency (Best, 1977, p.260).

Validity

A question which is of major concern in test construction is whether a test constructed actually measures what it was designed to measure. This is the question of the validity of the test. In this section, consideration is given to the content validity and the concurrent validity of the Cloze Reading Comprehension Test.

The content validity of the Cloze Test is in fact dependent on appropriateness of the process by which the technical prose materials were selected - given that the Cloze Test was intended to measure Thai science students' reading comprehension of first year science textbooks. The selection of science textbooks and of the sample passages was carefully made in an attempt to assure that the sample passages were free from any bias which might distort the result. The procedure of selecting the sample passages was provided in full detail in the previous chapter (see p. 85).

To estimate the concurrent validity of the cloze test as a measure of specific reading comprehension, the present study followed the procedure adopted in previous research (Anderson, 1976; Bormuth, 1967; Entin & Klare, 1978; Friedman, 1964; Jenkinson, 1957; Rankin & Culhane, 1969; Taylor, 1957). This entailed correlating the total score on the Cloze Reading Comprehension Test with the total score on the Multiple-choice Reading Comprehension Test, both constructed from the same reading passages. The correlation coefficient was $r = .63$ when the exact word scoring procedure was used with the Cloze Test and $r = .65$ when the acceptable word scoring procedure was applied. The reasonably substantial relationship between the two tests warrants the conclusion

that the concurrent validity is adequate (Best, 1977).

Multiple-choice Reading Comprehension Test: Administration

Test Booklet

In order to minimise bias, the test booklets were prepared in three different forms, each employing a different order of presentation (see Figure 5 below).

Title of the passage	Order of presentation		
	Form 1	Form 2	Form 3
Parasitic Reproduction	1	3	2
Covalent Bonds	2	1	3
Molecular Diffusion	3	2	1

Figure 5. Alternative Forms: Multiple-choice Reading Comprehension Test

Test Administration

All of the three forms of the Multiple-choice Reading Comprehension Test (three passages with 60 items in each form) were administered to the 190 students on July 30, 1979, a week after the administration of the Cloze Test.

The author met with the six lecturers for half an hour before the test was held to explain the test and distribute the instruction sheet (see Appendix K).

The test booklets had been distributed before the students took their seats. They were asked to take the answer sheet out of the back page of the test booklet and to write down names and Faculties on the space provided. They were allowed 45 minutes to complete each passage. They were also allowed to look back at the passage when they were answering the questions.

It should be noted that this procedure departs from the procedure adopted in most previous research testing the concurrent validity of the cloze tests. In most of the studies reviewed, (Anderson, 1976; Bormuth, 1967; Rankin & Culhane, 1969) after the Multiple-choice Reading Comprehension Test (constructed over the same passages as used in the Cloze Test) had been read by the subjects, it was taken away before they were asked to answer the question on the Multiple-choice Reading Test. There were two reasons why in the present study the subjects were allowed to answer the question while referring back to the passage read. The first arose out of an initial pilot testing carried out with four Thai post-graduate science students at Massey University, New Zealand. The subjects took the Cloze Test on November 3, 1978. A week later, they were given the same passage to read. Then they were asked to answer the questions of the Multiple-choice Reading Test without referring back to the passage. The subjects reported that they tended to guess the answers rather than express their reading comprehension in answering the questions. The second is a logical reason. The Reading Comprehension Test of this study was based on technical prose materials which required close reading. Removing the passage would cause too much weight to be placed on memory. In support, Carroll (1972) commenting on the testing of reading comprehension stated that:

If we do not permit reinspection of the paragraphs, we would certainly be emphasizing memory factors. The more typical manner of administering a reading comprehension test, however is to allow inspection of the paragraphs along with the questions.

(Carroll J.B., 1972, p.7)

Before the test was taken, the lecturers read with the students the test directions from the test booklet to make sure that everybody understood (see Appendix B).

Scoring Procedure

The students' answers to the test were hand scored twice, first by a fourth year science student, second by the author to check the accuracy of the marking. In marking the test, the scorers did not have to make any independent judgements because the key to the correct answers was prepared in advance (see Appendix L). Each correct answer was given one mark.

Results

The basic statistics of the Multiple-choice Reading Comprehension Test derived from the sample of 190 students are displayed in Table 26.

Table 26

Multiple-choice Reading Comprehension Test: Basic Statistics

Test Variable	N	Mean	Median	Range	SD
Multiple-choice Reading Comprehension Test (n = 60 items)	190	29.34	28.70	17-54	6.80

The item difficulty indices and the item discrimination indices were obtained from an item analysis of the 60 test items. Item difficulties ranged from .18 to .94. The internal validity, as measured by a biserial correlation between the test items and the total score, showed items with internal validities ranging from .01 to .43 (see Appendix M for the complete item statistics of the test).

Reliability

Internal consistency using the Kuder-Richardson Formula 20, was computed for all 60 items for the total sample. The reliability estimate obtained was .72, indicating that the test was a substantially reliable measure (Best, 1977, p.260).

Validity

The content validity of the Multiple-choice Reading Comprehension Test as a measure of reading comprehension rests on the following assumptions:

- (i) The passages included in the test are representatives of the kind of science reading materials which Thai science students at Khon Kaen University face in their reading at the first year university level. This was

assured by selecting the passages randomly from the set basic textbooks. The textbooks were suggested for their importance by the heads of the Departments of Physics, Chemistry, and Biology at Khon Kaen University. The detailed description for the selection of these passages can be found in the previous chapter (see p. 90).

- (ii) The sixty items of the test measure six reading comprehension skills. These skills include: knowledge of vocabulary found in the test passage, knowledge of stated facts, the ability to perceive causal relationships, the ability to make inferences, the ability to grasp the organization of a passage, and the ability to identify the main idea. These 60 items were checked for the accuracy of their science content by three qualified scientists, one a native speaker of English, the other two native speakers of Thai. The test items were also checked for correct use of language, as well as for construction by three language specialists who were native speakers of English. The items were also judged for their quality in measuring each particular comprehension skill. The test items were also subjected to item analysis. Attempts to ensure the internal validity of the test items involved item selection and item analysis.
- (iii) The students' reading comprehension of the passage used was inferred from the number of the correct answers given in the Multiple-choice Reading Comprehension Test. In order to show the validity of this assumption, it is necessary to rule out other alternative ways of getting the correct answer or ways that do not require understanding of the words or of the sentences.

The first alternative is that students get the correct answers by random guessing. This alternative can be ruled out by looking at the mean total score that is possible by random guessing. Since there are four choices per item, students have a 25 percent chance of getting the right answer on each item by guessing.

There are 60 items in the test. This makes 15 a chance score on the total test assuming that all choices are equally probable. The mean score of the sample studied was found to be 29.3. This is sufficiently different from 15 to rule out random guessing.

A second alternative is that students may choose some set of positions, for example, first, second, third, fourth response choice in doing the test. This was controlled by attempting to balance the position of the correct answer over all 60 items. The distribution of correct answers over positions was as follows:

- (a) First position = 15 items
- (b) Second position = 15 items
- (c) Third position = 15 items
- (d) Fourth position = 15 items

If students adopted the position strategy, their scores would be 15 correct. The score is sufficiently different from the students' mean score of 29.3 to rule out the alternative that students chose the answers by their position.

A third alternative is that the length of the multiple-choice response influences the students' choice. Students could adopt the strategy of choosing the shortest or the longest response in each item without reading the item stem or the four choices at all. Or they could actually read all the responses in each item and choose the longest one because it is the most complex. Thus the complexity of the response somehow might determine the performance on these items rather than the reading comprehension skill. An examination of the length of the responses appears to rule out this alternative (see Appendix N). An optimal strategy of choosing the longest sentence and in the cases where there are two longest sentences choose one randomly would only result in 18 correct. It appears that the alternative which deals with the length of the multiple-choice response can be safely ruled out. There is no possible non-comprehension strategy that students could adopt that

would result in a score close to the 29.3 average found.

In addition, the psychometric properties of the test are adequate.

The reliability of the test is .72 which is acceptable, although on the low side. The test can be regarded as moderately difficult, giving an average score of 29.34. Given difficulty indices ranging from .40 to .94, 70% of the total test items ($n = 42/60$) could be regarded as not difficult and 25% ($n = 15/60$) as fairly difficult with difficulty indices ranging from .20 to .39. Only one item had a difficulty index under .18.

Sixty-seven percent of the test items exhibited biserial correlation between .20 to .43. The test can be regarded as adequately discriminatory.

On the basis of these data, it was concluded that the psychometric properties of the test were satisfactory for the studied purpose.

English Grammmatical Structures Test: Administration

Test Administration

The test (45 items measuring comprehension of 15 English grammatical structures) was administered to the 190 students in the afternoon session, July 22, 1979.

As before, the author met with the six other lecturers half an hour before the administration of the test. The instructions for administering the test were explained (see Appendix D). Before the students entered the exam rooms, a test booklet and a vocabulary list were placed on their desks. When they had taken their seats, they were first asked to check whether they had both a test booklet and a vocabulary list. Then they were asked to take the answer sheet out of the back page of the test booklet and write down their names and their Faculties. Then they were asked to check whether their test booklet contained 12 pages of the test items, and the test instruction page. They were also asked to write down their names and Faculties on the space provided on the vocabulary list (see Appendix O). The proctor, then, explained how to use the vocabulary

list, by saying these words (English translation):

Whenever you face any unfamiliar words in your test booklet, look them up in the vocabulary list. You will get the meaning of the word in Thai. Remember to circle the number which precedes the word you want to look up for its meaning. For example, you want to know what "absorb" means. Look the word "absorb" up in the vocabulary list, you will find...

1. absorb ดูดซึม

Read the meaning and remember to also circle the number which precedes that word:

①. absorb ดูดซึม

Do not be afraid of using the vocabulary list.

Putting a circle on a number preceding the word when you want to know the meaning, does not mean that you will lose your mark. The purpose is only for analysis in this study.

Then the lecturer read out the test instructions from the test booklet, and made sure that every student understood them (see Appendix C for the test instructions). The students were told to complete the test within an hour and a half. They were also asked to hand in to their lecturers the answer sheet, the test booklet and the vocabulary list.

Scoring Procedure

The students' answers were hand scored twice using the punched key sheet prepared in advance (see Appendix E). They were first scored by a fourth year science student and then by the researcher. The purpose was to check the accuracy in marking the test. Each correct answer was given one mark.

Results

The basic statistics of the English Grammatical Structures Test derived from the sample of 190 students are displayed in Table 27.

Table 27

Test of English Grammatical Structures: Basic Statistics

Test Variable	N	Mean	Median	Range	SD
English Grammatical Structures Test (n = 45 items)	190	21.87	21.80	8-41	6.26

Item analysis was carried out over the 45 test items and yielded item difficulty indices ranging from .16 to .72. The internal validity as measured by a biserial correlation between the test items and the total score showed items with internal validities ranging from .04 to .55 (see Appendix P).

Reliability

The Kuder-Richardson Formula 20 reliability was computed for all 45 items for the total sample. The coefficient obtained was $r = .76$ indicating that the test was a substantially reliable measure (Best, 1977, p.260).

Validity

The content validity of the Test of English Grammatical Structures was achieved by submitting the original 45 test items to three science lecturers who independently evaluated each item using the following criteria:

- (i) all target sentences were meaningful in terms of scientific concepts involved
- (ii) all possible answers were regarded as correctly interpreted, unambiguous and the most appropriate for the test items.

Those target sentences judged inadequate were replaced. "Possible," answers and "distractors" judged inadequate were also revised. The revised test items were then submitted to two specialists in the field of teaching English as a foreign language, who independently evaluated each item using the following criteria:

- (i) Each target sentence was in fact a structure of the type supposedly being tested.
- (ii) The test question and the four choices were grammatically correct.
- (iii) The correct answer in each item conveyed a meaning equivalent to the sentence tested.

Items were accepted for the test if they were judged to be adequate by both specialists. If an item was judged adequate by one language specialist, but the other recommended revision, the researcher re-examined the item and decided whether it was to be revised. In the event, all of the test items needed revision according to the recommendation of the language specialists. None was omitted.

One further procedure was followed to establish the concurrent validity of the test as a measure of comprehension of English grammatical structures. It was undertaken by correlating English Grammatical Structures scores with English-Thai Translation Test of English Grammatical Structures scores. The Pearson product moment correlation coefficient between the two tests was $r = .61$, indicating a "substantial relationship" (Mehrens, W.H., and Lehman, I.J., 1975. p. 60)., and warranting a conclusion of concurrent validity.

English-Thai Translation Test of English Grammatical Structures: Administration

The English-Thai Translation Test (45 items measuring comprehension of 15 selected English grammatical structures) was administered to 190 students on July 26, 1979.

Again, the author met with the six lecturers half an hour before the test administration. Each lecturer was given an instruction sheet to follow (see Appendix Q). The test booklets and the vocabulary lists had been distributed before the students took their

seats (see Appendices R and O respectively). The students were asked to write down their names and their Faculties on the space provided on the test booklets and on the vocabulary list. They were reminded to circle the number preceding any word which they looked up for its meaning. They were told to translate each sentence into Thai as best they could. The test was planned to take two hours and a half to complete. However, when the test had been in progress only an hour, a disruption occurred through a storm damage to the Khon Kaen Electricity Plant. As the test was taken in the late evening (from 7 p.m. onwards) it was impossible to carry on without the lights. The students were therefore asked to leave the exam rooms, leaving their test booklets and the vocabulary lists on the desks. They were asked to come back to complete the test on July 30, 1979. One hundred and eighty-eight students duly did.

Scoring Procedure

The English-Thai translation of 45 English sentences were hand scored by the author. The marking was done by following the key to the correct interpretation of the sentences which had been prepared in advance as a result of the Pilot testing on a group of 10 science students from Mahidol University, Bangkok (see Appendix S). Each correctly translated sentence was given one mark. Exact equivalent translation was not required. It was the functional equivalence translation which was considered more important.

Results

The basic statistics of the English-Thai Translation Test of English Grammatical Structures derived from the sample of 188 students are presented in Table 28.

Table 28

English-Thai Translation Test of English Grammatical Structures:
Basic Statistics

Test Variable	N	Mean	Median	Range	SD
English-Thai Translation Test of English Grammatical Structures (n = 45 items)	188	20.73	20.30	4-41	6.86

Reliability

The Kuder-Richardson 20 reliability of the total test was .84. On the basis of .70 and .80 acceptability, it was concluded that the test of English-Thai translation of English grammatical structures was a substantially reliable measure (Best, 1977, p.260).

Validity

An attempt was made to test content validity. This was achieved by submitting the original 45 test items to three science lecturers who independently evaluated each item. The criteria used in judging each item was that all target sentences were meaningful in terms of their scientific concepts. Those target sentences which were judged inadequate according to the criteria were replaced. The revised test items then were submitted to two language specialists who independently evaluated each item. The criteria was that each target sentence was in fact a structure of the type supposedly being tested. Accordingly none of the target sentences was omitted.

CHAPTER 5

RESULTS

Introduction

In the previous chapter, the basic statistics derived from the use of the four tests were reported and their reliability and validity established. The data obtained from the application of the tests constitute the basis for examining in this chapter the research questions posed in the present study. The chapter is presented in four parts. The first deals with the findings on the relationship between comprehension of selected English complex structures which Thai science students encounter in reading science textbooks and their reading comprehension of scientific English discourse. The second part reports data in support of the criteria for the division of two reading ability groups. The third part reports on the relationship found between reading ability and comprehension of English complex structures. Finally, the findings on the relative comprehensibility levels of English complement, comparative and relative structures for good and poor readers are described.

Findings: Relationship Between Comprehension of English Complex Structures and Reading Comprehension of Scientific English Discourse

Research Question 1: Does there exist a relationship between the ability to comprehend longer passages of scientific English and the ability to comprehend complement, relative and comparative structures?

On the basis of previous research, it was hypothesized that Thai science students' comprehension of complex structures would be positively related to their reading comprehension of scientific English passages. This hypothesis was tested by a correlational analysis. The scores from the Test of English Grammatical Structures, the Cloze Reading Comprehension Test and the scores from the Multiple-choice Reading Comprehension Test were entered into the analysis.

Product-moment correlations

The Product-moment correlations were calculated between (i) the scores from the Test of English Grammatical Structures and the scores from the Cloze Reading Comprehension Test, and (ii) the scores from the Test of English Grammatical Structures and the scores from the Multiple-choice Reading Comprehension Test. Table 29 presents results.

Table 29

Correlation Between Structure Comprehension and Reading Comprehension (N=190)

Variable	Cloze Reading Comprehension Test	Multiple-choice Reading Comprehension Test
Test of English Grammatical Structures	.650 ^{***}	.659 ^{***}

p < .001

The correlation between the Test of English Grammatical Structure and the Cloze Reading Comprehension Test is significant and moderately high ($r = .65$) with 42 percent of the variance accounted for by the Test of English Grammatical Structures. The relationship between the Test of English Grammatical Structures and the Multiple-choice Reading Comprehension Test is also significant and moderately high ($r = .66$). For the Multiple-choice Reading Comprehension Test, 43 percent of the variance is accounted for by the Test of English Grammatical Structures. The results support the prediction. The Pearson-product moment correlations support hypothesis 1.

Partial Correlations

One important point to be considered when a correlational analysis is carried out is whether a third variable may have exerted as an intervening influence. For the present study, one variable which the Test of English Grammatical Structures could be measuring and which is also

related to reading comprehension is knowledge of word meanings. The obtained correlation coefficients between structure comprehension scores and reading comprehension scores might be largely explainable by this third variable. The original correlation may be somewhat spurious, and the third variable the important one. To examine this possibility, partial correlations were run between the Test of English Grammatical Structures and the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test with the KKU Vocabulary Sub-test partialled out. Table 30 presents the correlational matrix for structure comprehension scores, reading comprehension scores and vocabulary scores. The partial correlations are shown in Table 31.

Table 30

Correlational Matrix: Structure Comprehension Scores,
Reading Comprehension Scores and Vocabulary Scores

Variable	1	2	3	4
1 Test of English Grammatical Structures		.650 ^a	.659	.517
2 Cloze Reading Comprehension Test			.626	.537
3 Multiple-choice Reading Comprehension Test				.560
4 KKU Vocabulary Sub-test				

^aFor all coefficients $p < .001$

Table 31

Partial Correlations: Structure Comprehension Scores and
Reading Comprehension Scores with Vocabulary Scores Controlled

Variable	r	Partial Correlations with Vocabulary Scores Controlled
Test of English Grammatical Structures vs Cloze Reading Comprehension Test	.650 ^a	.51
Multiple-choice Reading Comprehension Test	.659	.52

^aFor all coefficients $p < .001$

Using a variance interpretation, the proportion of overlap between structure comprehension scores and cloze scores which results from the effect of vocabulary is .16 (i.e., $.65^2 - .51^2$).

The proportion of overlap between structure comprehension scores and multiple-choice reading scores which results from the effect of vocabulary is .15 ($.65^2 - .52^2$).

The partial correlations show therefore that the third variable cannot be regarded as explaining much of the relationship between the Test of English Grammatical Structures and the Reading Comprehension Tests. Very little of the relationship between the Test of English Grammatical Structures and the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test can be accounted for by vocabulary. These data provide further support for hypothesis 1.

Sex

In order to assess whether hypothesis 1 had differential sex effects, male and a female data subgroups were formed, and t-test analyses being performed for each subgroup. As can be seen from Table 32 differences

in mean scores between subgroups are not statistically significant.

Table 32

Comparisons of Means for Males and Females

Variable	Male (N=80)		Female (N=110)		T-Ratio	Probab- ility
	Mean	SD	Mean	SD		
Test of English Grammm- atical Structures	22.64	6.59	21.31	5.98	1.45	N.S.
Cloze Reading Comprehension Test	28.90	8.16	28.58	6.45	0.30	N.S.
Multiple-choice Reading Comprehension Test	30.09	7.82	28.79	5.92	1.30	N.S.
KKU Vocabulary Sub-test	6.96	3.86	6.54	2.90	0.87	N.S.

Table 33 presents the Pearson product moment correlations differentiated by sex for: (i) the Test of English Grammmatical Structures and Cloze Reading Comprehension Test by sex and (ii) the Test of English Grammmatical Structures and the Multiple-choice Reading Comprehension Test by sex.

Table 33

Correlations between Structure Comprehension Scores and Reading
Comprehension Scores by Sex

Variable	Cloze Reading Comprehension Test		Multiple-choice Reading Comprehension Test	
	Male (80)	Female (110)	Male (80)	Female (110)
Test of English Grammatical Structures	.72 ^a	.58	.77	.54

^aFor all coefficients $p < .001$

The significant and quite substantial correlations in Table 33 support hypothesis 1 for both males and females. Fifty-one percent of the variance is accounted for by the Test of English Grammatical Structures for males and 34 percent for females. The difference between the correlations for males and females, using Fisher's z transformation test, is not statistically significant ($z = 1.74$) (Ferguson, 1976, p.184).

The relationship between the Test of English Grammatical Structures and the Multiple-choice Reading Comprehension Test is significant for both male group ($r = .77$) and female group ($r = .54$). Fifty-nine percent of the variance is accounted for by the Test of English Grammatical Structures for males and 29 percent for females. The difference between the correlation coefficients for males and females, using Fisher's z transformation test is statistically significant ($z = 2.95$).

Conclusions

- (i) The ability of Thai science students to comprehend English complex structures was found related to their reading comprehension of scientific English passages, as measured by the Cloze Test ($r = .65$) and by the Multiple-choice Reading Comprehension Test ($r = .66$).

- (ii) No sex differences were found in ability to comprehend
- (i) English complex structures as measured by the Test of English Grammatical Structures, (ii) scientific English passages as measured by both the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test, and (iii) vocabulary as measured by the KKU Vocabulary Sub-test.
- (iii) No sex differences were found in the relationship between ability to comprehend English complex structures and reading comprehension of scientific English passages as measured by the Cloze Reading Comprehension Test (males, $r = .72$; females, $r = .58$).
- (iv) The correlation coefficient between the ability to comprehend English complex structures and reading comprehension of scientific English passages as measured by the Multiple-choice Reading Comprehension Test was found to be higher for males ($r = .77$) than for females ($r = .54$). The difference was statistically significant.

Difference Between Reading Performance of Two Reading Ability Groups

Because the research questions 2 and 3 focused on Thai science students who differed in reading proficiency in EST, high and low reading ability groups had to be identified. To achieve this, the 190 students were selected and placed in high and low groups, using the upper and the lower third of the distribution of cloze reading scores (approximated ± 1 SD) as the criterion. See the distribution of cloze reading scores in Appendix T. Students with scores above 34 on the Cloze Reading Comprehension Test were placed in the "high" group and those with scores below 24 were placed in the "low" group. As a result, there were 40 students in the "high" group, and 43 students in the "low" group (see individual cloze reading scores of both groups in Table 34).

In order to see if the previously identified high and low groups were divided appropriately, individual reading scores from the Cloze Reading Comprehension Test were compared to individual reading scores from the Multiple-choice Reading Comprehension Test (see Table 34).

Table 34

Raw Scores and Percent Correct Responses on the Cloze Reading Comprehension
and the Multiple-choice Reading Comprehension Test for each of 83 students

Student	Cloze Reading Comprehension Test		Multiple-choice Reading Comprehension Test		Student	Cloze Reading Comprehension Test		Multiple-choice Reading Comprehension Test	
	Raw Score	Percentage	Raw Score	Percentage		Raw Score	Percentage	Raw Score	Percentage
1	52	57.7	54	90.0	45	23	25.5	23	38.3
2	47	52.2	41	68.3	46	23	25.5	20	33.3
3	45	50.0	40	66.6	47	23	25.5	26	43.3
4	44	48.8	42	70.0	48	23	25.5	28	46.6
5	44	48.8	53	88.3	49	23	25.5	34	56.6
6	44	48.8	35	58.3	50	23	25.5	23	38.3
7	42	46.6	35	58.3	51	23	25.5	32	53.3
8	42	46.6	35	58.3	52	22	24.4	23	38.3
9	41	45.5	21	35.0	53	22	24.4	28	46.6
10	41	45.5	42	70.0	54	22	24.4	33	55.0
11	41	45.5	40	66.6	55	22	24.4	17	28.3
12	40	44.4	26	43.3	56	22	24.4	29	48.3
13	39	43.3	47	78.3	57	22	24.4	30	50.0
14	39	43.3	41	68.3	58	22	24.4	25	41.6
15	39	43.3	38	63.3	59	21	23.3	24	40.0
16	39	43.3	34	56.6	60	21	23.3	28	46.6
17	39	43.3	43	71.6	61	21	23.3	18	30.0
18	38	42.2	43	71.6	62	20	22.2	26	43.3
19	38	42.2	41	68.3	63	20	22.2	27	45.0
20	38	42.2	40	66.6	64	20	22.2	24	40.0
21	38	42.2	39	65.0	65	20	22.2	18	30.0
22	38	42.2	32	53.3	66	19	21.1	25	41.6
23	38	42.2	35	58.3	67	19	21.1	27	45.0
24	38	42.2	37	61.6	68	19	21.1	18	30.0
25	38	42.2	37	61.6	69	18	20.0	26	43.3
26	37	41.1	43	71.6	70	18	20.0	24	40.0
27	37	41.1	26	43.3	71	18	20.0	25	41.6
28	37	41.1	26	43.3	72	17	18.8	31	51.6
29	37	41.1	33	55.0	73	17	18.8	22	36.6
30	36	40.0	39	65.0	74	17	18.8	26	43.3
31	36	40.0	31	51.6	75	17	18.8	30	50.0
32	36	40.0	25	41.6	76	16	17.7	30	50.0
33	36	40.0	18	30.0	77	16	17.7	20	33.3
34	35	38.8	31	51.6	78	16	17.7	22	36.6
35	35	38.8	42	70.0	79	16	17.7	25	41.6
36	35	38.8	29	48.3	80	15	16.6	28	46.6
37	35	38.8	32	53.3	81	14	15.5	23	38.3
38	35	38.8	32	53.3	82	13	14.4	17	28.3
39	35	38.8	29	48.3	83	10	11.1	18	30.0
40	35	38.8	36	60.0					
41	23	25.5	35	58.3					
42	23	25.5	33	55.0					
43	23	25.5	23	38.3					
44	23	25.5	19	31.6					

Median = 23.4		Median = 29.3	
(26.0%)		(48.8%)	
(N = 83)		(N = 83)	

The students were divided into high and low scoring groups, using the median scores on both the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test for the combined groups (N = 83) as the criterion. Students with scores at or above the median score on both tests were placed in the high group and those with scores below the median score on both tests were placed in the low group. Each student was then assigned to a high or a low category on each of the two tests. A two-by-two matrix was constructed showing the placement of all students in each of the four possible categories in order to determine (i) if the placement differentiated significantly between high and low reading ability groups, and (ii) if the relationship between scores on the Cloze Reading Comprehension Test and the Multiple-choice Reading Comprehension Test was statistically significant. Table 30 presents these results.

The data in Table 35 indicate considerable consistency between test scores. Only 20 percent of the total number of results displayed "inconsistency". Eight students (lower left-hand quadrant scored higher than the Cloze Test median of 23.4 (26%) but lower than the Multiple-choice Reading Comprehension Test median of 29.3 (48.8%)) and nine students (upper right hand quadrant scored lower than the median on the Cloze Test but higher than the median on the Multiple-choice Reading Comprehension Test). The majority of the students were consistent in their performance on both tests and reading ability of the two groups was shown to be significantly different.

Table 35

Placement of students in High and Low Scoring Groups Based on
the Median of Both Cloze Reading Comprehension Test and the
Multiple-choice Reading Comprehension Test

		Cloze Reading Comprehension Test		
		High (at or above median 23.4)	Low (below median 23.4)	Total
Multiple-choice Reading Comprehension Test	High (at or above median 29.3)	32	9	41
	Low (below median 29.3)	8	34	42
	Total	40	43	83

$$\chi^2 = 28.9 \text{ (df = 1); } p < .001$$

$$\text{Gamma } (\gamma) = .88$$

Findings: Relationship Between Good and Poor Readers'
Comprehension of the 15 English Complex Structures

Research Question 2: Within the respective groups of good and poor readers, are the patterns of the comprehensibility levels of complement, relative and comparative structures similar?

The above research question is concerned with the relationship between reading ability and the comprehensibility of the 15 complex structures under investigation. Table 36 and 37 show respectively for good and poor readers, the comprehension scores, their means and standard deviations for each of the 15 structures, ranked from easiest to most difficult. The comprehension scores were derived from 45 items - three for each of the 15 structures. Of the 15 structures, five were of the complement type, five of the comparative type and five of the relative structure type. Each structure is indicated in the tables. Each comprehension score was derived by adding together the number of correct responses to the appropriate three questions. The results for each group of readers will be dealt with separately.

For the good readers, scores ranged from 108 to 46 (for each structure). Given three sentences in each and an $N = 40$, this means that for the top score nearly all students got all three sentences correct and for the bottom score most got one answer correct. The percentage scores ranged from 90 to 38.3. The percentage score column shows the percent of total correct responses for each structure obtained by dividing the actual obtained correct responses by the possible correct responses (in this case, 120). The mean score column shows the average number of items correct for each structure. The standard deviation column reveals the average distance where the individual scores in a distribution are removed from the mean. The greater the value of the standard deviation, the further the original score is removed from the mean.

Table 36

Comprehension Scores of the 15 English Complex Structures of Good Readers (N = 40), Ranked from Easiest to Most Difficult

Structure Number	Description of Structures	Comprehension Scores		Mean	SD
		raw scores	Percentage		
7	Comparison of Inequality (with <u>than</u>)	108	90.0	2.70	.516
5	Participial -ing Complement after preposition	95	79.1	2.38	.837
14	Finite (<u>which</u> -subject) Relative	91	75.8	2.28	.876
9	Comparison of Similarity (same)	86	71.6	2.15	.833
15	Finite (<u>which</u> -complement to preposition) Relative	83	69.1	2.08	.764
13	Finite (<u>that</u> -subject) Relative	80	66.6	2.00	.877
11	Non-finite (- <u>ed</u> / <u>-en</u>) Relative	80	66.6	2.00	.679
1	Finite Object Complement	76	63.3	1.88	.790
4	Finite Subject Complement	68	56.6	1.70	.911
12	Non-finite (- <u>ing</u>) Relative	68	56.6	1.70	.822
2	Non-finite (to-infinitive) Object Complement (type 2)	60	50.0	1.50	.847
8	Comparison of Difference (<u>other</u>)	59	49.1	1.48	.750
10	Comparison of Equality (<u>as</u> -relative like)	55	45.8	1.38	.978
6	Comparison of Inequality (\emptyset <u>than</u>)	51	42.5	1.28	.846
3	Non-finite (to-infinitive) Object Complement (type 5)	46	38.3	1.15	.863

Table 37

Comprehension Scores of 15 English Complex Structures of Poor Readers (N = 43), Ranked from Easiest to Most Difficult

Structure Number	Description of Structures	Comprehension Scores		Mean	SD
		raw scores	Percentage		
7	Comparison of Inequality (with <u>than</u>)	62	48.0	1.47	.959
9	Comparison of Similarity (<u>same</u>)	61	47.2	1.42	1.028
14	Finite (<u>which</u> -subject) Relative	60	46.5	1.40	.876
15	Finite (<u>which</u> -complement to preposition) Relative	60	46.5	1.40	.903
13	Finite (<u>that</u> -subject) Relative	57	44.1	1.33	.808
5	Participial -ing Complement after Preposition	56	43.4	1.30	.887
1	Finite Object Complement	56	43.4	1.30	.802
4	Finite Subject Complement	53	41.0	1.23	.895
12	Non-finite (- <u>ing</u>) Relative	46	35.6	1.07	.827
6	Comparison of Inequality (\emptyset <u>than</u>)	46	35.6	1.07	.827
8	Comparison of Difference (<u>other</u>)	44	34.1	1.02	.801
11	Non-finite (- <u>ed</u> / <u>-en</u>) Relative	43	33.3	1.00	.654
3	Non-finite (to-infinitive) Object Complement (type 5)	38	29.4	.88	.762
10	Comparison of Equality (<u>as</u> -relative like)	33	25.5	.77	.840
2	Non-finite (to-infinitive) Object Complement (type 2)	30	23.2	.70	.860

Poor readers, scores ranged from 62 to 30. Given three sentences in each structure and an $N = 43$, this means that for the top score, most of the students got one answer correct and for the bottom score, only some of the students got one answer correct. The percentage scores ranged from 48 to 23.2. Each percentage score was determined by dividing obtained correct responses by possible correct responses (in this case, 129) multiplied by 100 over 1. The mean score column (Table 37) shows the average number of items correct for each structure. The standard deviation column shows the average distance where the individual scores in a distribution are removed from the mean.

In order to determine whether the patterns of the comprehensibility levels of 15 structures for good and poor readers were similar, comprehension ranks rather than comprehension scores of the 15 structures were used as the basis for comparing the two ability groups. Table 38 compares comprehension ranks of 15 structures for both groups. So regardless of whether the comprehension score was 90 percent (as were the good readers' comprehension scores on comparison of inequality with than) or 48 percent (as were the poor readers' comprehension scores on the same structure), the important point is that, in relation to other structures, this particular structure was the most comprehensible for both groups to read. In this way, ranking would be appropriate to provide information which could answer the previous research question.

Spearman rank-order correlation

In order to find the relationship between good reader's and poor reader's comprehension of 15 English structures, a Spearman rank-order correlation was computed. The results are presented in Table 39.

Table 38

Comprehension Scores and Comprehension Ranks of 15 Complex Structures for Good (N = 40) and Poor Readers (N = 43)

Structure Number	Description of Structures	Good Readers			Poor Readers		
		Scores	%	Ranks	Scores	%	Ranks
7	Comparison of Inequality (with <u>than</u>)	108	90.0	1	62	48.0	1
5	Participial -ing Complement after Preposition	95	79.1	2	56	43.4	6.5
14	Finite (<u>which</u> - subject) Relative	91	75.8	3	60	46.5	3.5
9	Comparison of Similarity (<u>same</u>)	86	71.6	4	61	47.2	2
15	Finite (<u>which</u> - complement to preposition) Relative	83	69.1	5	60	46.5	3.5
13	Finite (<u>that</u> - subject) Relative	80	66.6	6.5	57	44.1	5
11	Non-finite (-ed/-en) Relative	80	66.6	6.5	43	33.3	12
1	Finite Object Complement	76	63.3	8	56	43.4	6.5
4	Finite Subject Complement	68	56.6	9.5	53	41.0	8
12	Non-finite (-ing) Relative	68	56.6	9.5	46	35.6	9.5
2	Non-finite (<u>to</u> -infinitive) Object Complement (Type 2)	60	50.0	11	30	23.2	15
8	Comparison of Difference (<u>other</u>)	59	49.1	12	44	34.1	11
10	Comparison of Equality (<u>as</u> - relative-like)	55	45.8	13	33	25.5	14
6	Comparison of Inequality (\emptyset than)	51	42.5	14	46	35.6	9.5
3	Non-finite (to-infinitive) Object Complement (Type 5)	46	38.3	15	38	29.4	13

Table 39

Spearman Rank-order Correlation Coefficient Between Good
Readers' and Poor Readers' Comprehension of English
Complex Structures

Variable	Poor Readers' Comprehension of 15 English Structures
Good Readers' Comprehension of 15 English Structures	.81

p < .001

The correlation coefficient of .81 in Table 39 indicates a strong relationship statistically significant at the .001 level. This implies that in relation to other structures investigated, those structures which are comprehensible for good readers, tend to be comprehensible for poor readers also, and those structures which are difficult for good readers, tend also to be difficult for poor readers.

To find out further which particular structures are at similar levels of comprehensibility for both groups, the structures were classified into "most comprehensible", "moderately difficult" and "most difficult" categories. Assignments were made so that both groups would have the same number of structures in each of the three categories, as shown in Table 40.

As the table shows, for the group of good readers, five structures classified under the "most comprehensible" category were two types of comparisons (Structures number 7 & 9), two types of relatives (Structures number 14 & 15) and one complement (Structure number 5). Five other structures grouped within the "most difficult" category, were three types of comparisons (Structures number 6, 8 & 10) and two types of complements (Structures number 2 & 3). Moderately difficult structures included three types of relatives (Structures number 11, 12 & 13) and two types of complements (Structures number 1 & 4). When

Table 40

Most Comprehensible, Moderately Difficult and Most Difficult Ranking
Structures for Good Readers and Poor Readers

<u>Good Readers (N = 40)</u>			<u>Poor Readers (N = 43)</u>		
Comprehension Rank	Structure Number	Description of Structure	Comprehension Rank	Structure Number	Description of Structures
Most Comprehensible	1	Comparison of Inequality (with <u>than</u>)	1	7	Comparison of Inequality (with <u>than</u>)
	2	Participial -ing Complement after preposition	2	9	Comparison of Similarity (<u>same</u>)
	3	Finite (<u>which</u> -subject) Relative	3.5	14	Finite (<u>which</u> -subject) Relative
	4	Comparison of Similarity (<u>same</u>)	3.5	15	Finite (<u>which</u> -complement to preposition) Relative
	5	Finite (<u>which</u> -complement to preposition) Relative	5	13	Finite (<u>that</u> -subject) Relative
Moderately Difficult	6.5	Finite (<u>that</u> -subject) Relative	6.5	5	Participial -ing Complement after Preposition
	6.5	Non-finite (-ed/-en) Relative	6.5	1	Finite Object Complement
	8	Finite Object Complement	8	4	Finite Subject Complement
	9.5	Finite Subject Complement	9.5	12	Non-finite (-ing) Relative
	9.5	Non-finite (-ing) Relative	9.5	6	Comparison of Inequality (\emptyset than)
Most Difficult	11	Non-finite (to-infinitive) Object Complement (Type 2)	11	8	Comparison of Difference (<u>other</u>)
	12	Comparison of Difference (<u>other</u>)	12	11	Non-finite (-ed/-en) Relative
	13	Comparison of Equality (<u>as</u> -relative like)	13	3	Non-finite (to-infinitive) Object Complement (Type 5)
	14	Comparison of Inequality (\emptyset than)	14	10	Comparison of Equality (<u>as</u> -relative like)
	15	Non-finite (to-infinitive) Object Complement (Type 5)	15	2	Non-finite (to-infinitive) Object Complement (Type 2)

comparisons, complements, and relatives were examined separately, it appeared that none of the relative structures were found under the "most difficult" category. In other words, relatives seem not to cause reading difficulty for this group. Comparisons and complements on the other hand, were found to be either very difficult or most comprehensible for the group.

For poor readers, structures within the "most comprehensible" category were two types of comparisons (Structures number 7 & 9) and three types of relatives (Structures number 13, 14 & 15). Those structures under the "most difficult" category were found to be two types of comparisons (Structures number 8 & 10), two complements (Structures number 2 & 3) and one relative (Structure number 11). The structures grouped within the "moderately difficult" category were three types of complements (Structures number 1, 4 & 5), one relative (Structure number 12) and one comparison (Structure number 6).

The pattern which emerged from a closer examination of complements, comparisons and relatives taken separately, was that none of the complement structures were found under the "most comprehensible" category for the group of poor readers. The complements clustered under the "moderately difficult" category (Structures number 1, 4 & 5) and the "most difficult" category (Structures number 2 & 3). Comparisons and relatives, on the other hand, were found either within the "most comprehensible" or the "most difficult" category. For example, comparison of inequality (with than) and comparison of similarity (same) were found to be very easy while comparison of difference (other) and comparison of equality (as - relative like) were very difficult for poor readers. All finite relatives were found very easy for the group while the non-finite (-ed/-en) relative was most difficult.

When the structures that occurred within the same comprehension category for both groups were examined it was found that the same four structures were difficult for both groups to read and the same four other structures were easy for both groups to read. Figure 6 illustrated the number of structures that occurred within the three comprehension categories for both groups.

Percentage of
Comprehension Scores

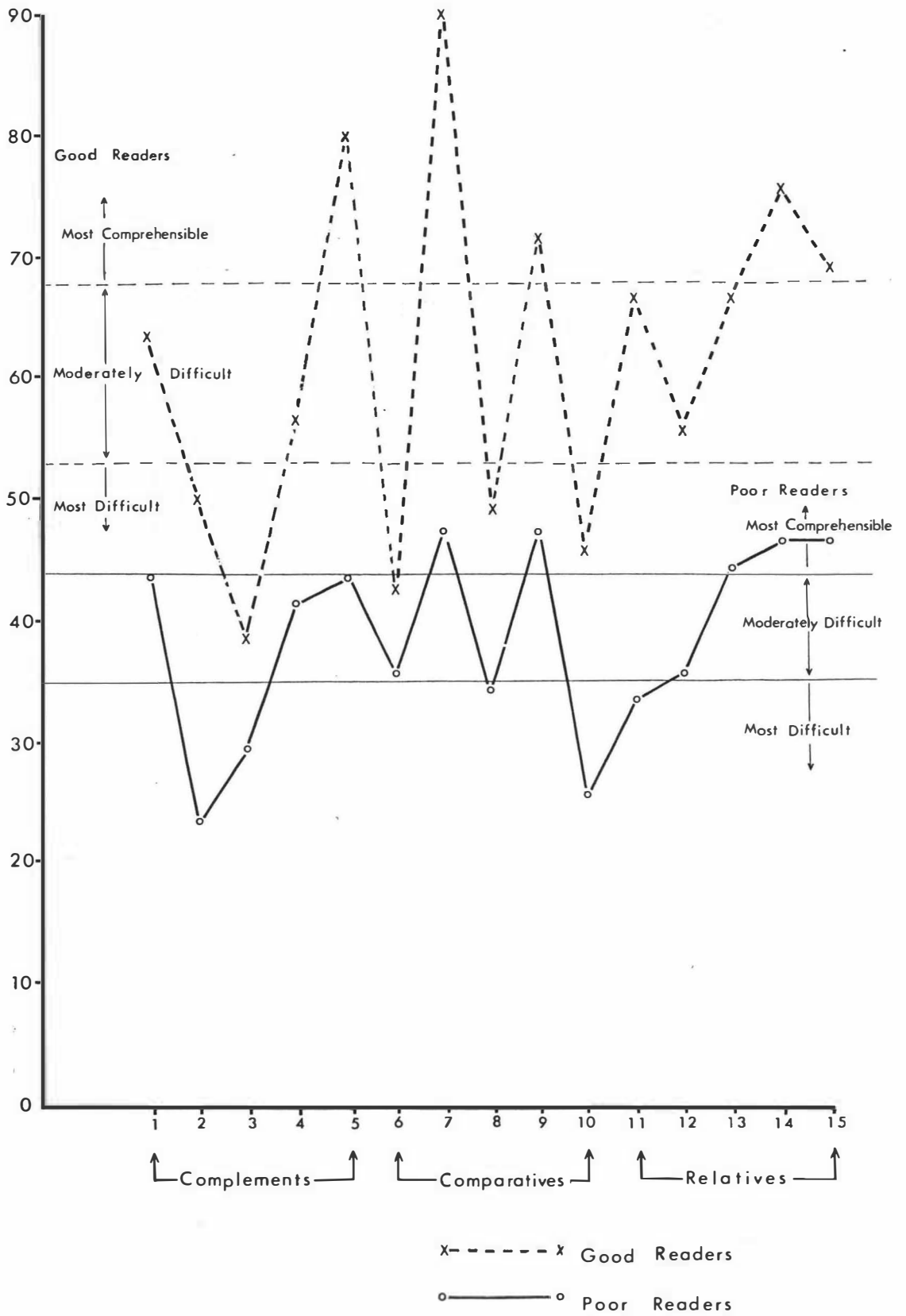


Figure 6: Number of structures that occurred within the three comprehension categories for both groups

A closer examination of the structures within the same comprehension category reveals that comparison of inequality (with than), comparison of similarity (same), finite (which-subject) relative and finite (which-complement to preposition) relative are easy to comprehend for both groups of readers. Comparison of equality (as - relative like), comparison of difference (other) and two types of non-finite object complement were found to cause reading difficulty for the two groups. Three structures were found moderately difficult for both groups viz., finite object complement, finite subject complement and non-finite (-ing) relative. Only four structures were found not to be in the same rank category for both groups. These included participial -ing complement after preposition, comparison of inequality (\emptyset than), non-finite (-ed/-en) relative and finite (that - subject) relative (see Table 41).

Conclusions

- (i) The comprehensibility levels of the 15 complex structures investigated displayed similar patterns for both good and poor readers. This was indicated by the strong correlation coefficient of $r = .81$. This implies that generally those structures which tend to be difficult for good readers, in relation to the other structures, tend to be difficult for poor readers also. Those structures which are comprehensible for good readers, tend to be comprehensible for poor readers also.
- (ii) The structures which were the easiest for both groups were Comparisons 7 and 9 and Relatives 14 and 15.
- (iii) The structures which were moderately difficult for both groups were Complements 1 and 4 and Relatives 12.
- (iv) The structures which were the most difficult for both groups are Complements 2 and 3 and Comparisons 8 and 10.
- (v) The structures which were not at the same level of comprehensibility when compared to the other structures, for both groups, were Complement 5, Comparison 6, Relatives 11 and 13.

Table 41

English Complex Structures with Similar and Dissimilar Comprehension Ranks
for Both Good Readers and Poor Readers

A. English Complex Structures within the Same Rank Category for Both Groups

<u>Structure Number</u>	<u>Most Comprehensible Category</u>
7	Comparison of Inequality (with <u>than</u>)
9	Comparison of Similarity (<u>same</u>)
14	Finite (<u>which</u> -subject) Relative
15	Finite (<u>which</u> -complement to preposition) Relative
	<u>Moderately Difficult Category</u>
1	Finite Object Complement
4	Finite Subject Complement
12	Non-finite (-ing) Relative)
	<u>Most Difficult Category</u>
3	Non-finite (<u>to</u> -infinitive) Object Complement (Type 5)
2	Non-finite (<u>to</u> -infinitive) Object Complement (Type 2)
10	Comparison of Equality (<u>as</u> -relative like)
8	Comparison of Difference (<u>other</u>)

B. English Complex Structures Not in the Same Rank Category for Both Groups

<u>Structure Number</u>	<u>Description of Structures</u>	<u>Good Readers</u>	<u>Poor Readers</u>
5	Participial (-ing) Complement	Most Comprehensible	Moderately Difficult
6	Comparison of Inequality	Most Difficult	Moderately Difficult
11	Non-finite (-ed/-en) Relative	Moderately Difficult	Most Difficult
13	Finite (<u>that</u> -subject) Relative	Moderately Difficult	Most Comprehensible

Findings: Differences in the Comprehensibility Levels of English Complex Structures for Good and Poor Readers

A major purpose of the present study was to find out (i) the comprehensibility levels of three main types of English complex structures -- complement, comparative and relative structures, and (ii) the comprehensibility levels of different manifestations of complement, comparative and relative structures taken separately, for good and poor Thai science readers. Results are presented in four separate headings below.

Comprehensibility levels of three main types of English complex structures -- complements, comparatives and relatives

Table 42 shows the comprehension scores, means and standard deviations for each of the three types of English complex structures under investigation for good and poor readers respectively. The comprehension raw scores of each type were derived by adding together the number of correct responses to the 15 items which were designed to test the same type of structure. The results for each group of readers will be dealt with separately.

For good readers, comprehension scores for the complements, the comparatives and the relatives were 345, 359 and 402 respectively. Their percentage scores of 57.5, 59.8 and 67.0 were obtained from a division of the actual obtained correct responses by the possible correct responses (in this case, were 600). The mean score column shows the average number of items correct for each type of complex structures (the total number of items for each type was 15).

For the poor readers, comprehension scores of the complements, the comparatives and the relatives were 233, 246 and 266 respectively. Their percentage scores were 36.1, 38.1 and 41.2.

Table 42

Comprehension Scores, Means and Standard Deviations of the Three Types of English Complex Structures for Good (N = 40) and Poor Readers (N = 43)

Types of Complex Structures	Raw Scores	Percentage	Mean	SD
<u>Complements</u>				
Good Readers	345	57.5	8.60	2.32
Poor Readers	233	36.1	5.42	2.14
<u>Comparatives</u>				
Good Readers	359	59.8	8.98	2.43
Poor Readers	246	38.1	5.74	2.32
<u>Relatives</u>				
Good Readers	402	67.0	10.05	2.43
Poor Readers	266	41.2	6.19	2.15

To test for differences in the comprehensibility levels of the three types of complex structures for good and poor readers, the comprehension scores were analyzed separately for each group by means of a single-factor analysis of variance (repeated measures) design (Keppel, 1973). Scheffe' multiple comparisons were performed to test for significance of the differences between adjacent means. Both are discussed below.

Single-factor analyses of variance (repeated measures). Single-factor analyses of variance (repeated measures) were calculated on each of the two reading ability groups across the comprehension scores of three types of complex structures. The results of the analyses on good and poor readers are presented in Tables 43 and 44 respectively.

Table 43

Summary of a Single-factor Analysis with Repeated Measures
of Good Readers (N = 40) by Types of Complex Structure

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of Complex Structure)	45.32	2	22.66	7.75 ^{***}
S (Subjects)	442.46	39	11.35	
A x S	228.02	78	2.92	
Total	715.79	119		

p < .001

Table 44

Summary of a Single-factor Analysis with Repeated Measures
of Poor Readers (N = 43) by Types of Complex Structure

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of Complex Structure)	12.76	2	6.38	1.66 N.S.
S (Subjects)	289.92	42	6.90	
A x S	323.24	84	3.85	
Total	625.92	128		

As Table 43 shows, for good readers, the between structures variation ($F = 7.75$, $df = 2, 119$) was significant at the .001 level. Scheffé multiple comparisons were performed to determine which type of

English complex structure was significantly more comprehensible than the others (see Appendix U). The results revealed that relatives are significantly more comprehensible than complements ($F = 14.38$) and comparatives ($F = 7.98$). No significant difference, however, was observed between complements and comparatives.

As Table 44 indicates, for poor readers, the data in Table 44 indicated that the overall differences were not significant ($F = 1.66$, $df = 2, 128$).

Figure 7 compares the comprehensibility levels of the two groups in the three complex structure types.

Mean scores

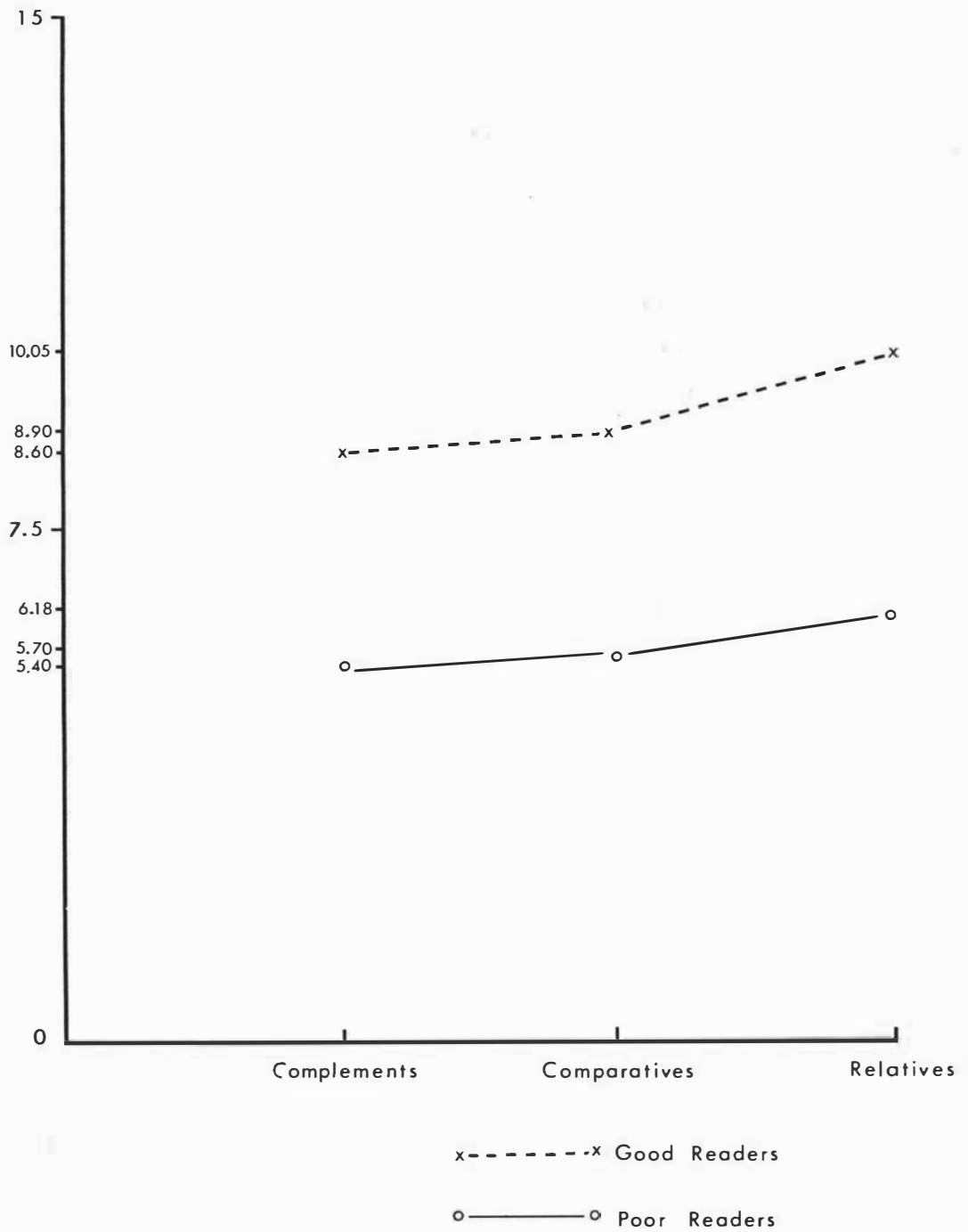


Figure 7: Comprehensibility Levels of three main types of English complex structure (complements, comparatives, relatives) for good and poor readers

Comprehensibility levels of the five different manifestations
of English complements for good and poor readers

Table 45 shows comprehension scores, means and standard deviations for each of the five complements, for good and poor readers.

Table 45

Comprehension Scores, Means and Standard Deviations of the
Five Complements for Good (N = 40) and Poor Readers (N = 43)

Types of Complements	Raw Scores	Percentage	Mean	SD
<u>Complement 1</u>				
Good Readers	76	63.3	1.88	.79
Poor Readers	56	43.4	1.30	.80
<u>Complement 2</u>				
Good Readers	60	50.0	1.50	.85
Poor Readers	30	23.2	.70	.86
<u>Complement 3</u>				
Good Readers	46	38.3	1.15	.86
Poor Readers	38	29.4	.88	.76
<u>Complement 4</u>				
Good Readers	68	56.6	1.70	.91
Poor Readers	53	41.0	1.23	.90
<u>Complement 5</u>				
Good Readers	95	79.1	2.38	.84
Poor Readers	56	43.4	1.30	.89

For good readers, comprehension raw scores ranged from 95 to 46 (for each complement structure). Each comprehension raw score was derived by adding together the number of correct responses to the appropriate three questions. The percentages ranged from 79.1 to 38.3. The percent of total correct responses for each structure was obtained

by dividing the actual obtained correct responses by the possible correct responses (120 per each structure). The mean score column shows the average number of items correct for each structure (three items for each structure).

For poor readers, the comprehension raw scores ranged from 56 to 30 (for each complement structure). The percentage score column shows the percent of total correct responses for each complement structure. The percentages ranged from 43.4 to 23.2.

To determine whether there were any differences in the comprehensibility levels of the five complements for good and poor readers, the comprehension scores were analyzed separately for each group by means of a single-factor analysis of variance (repeated measures) design (Keppel, 1973). Scheffé' multiple comparisons were performed to test for significance of the differences between adjacent means. Both are discussed below.

Single-factor analyses of variance (repeated measures). Single-factor analyses of variance (repeated measures) were calculated on each of the two reading ability groups across the comprehension scores of the five complement structures. The results of the analyses on good and poor readers are presented in Table 46 and 47 respectively.

Table 46

Summary of a Single-factor Analysis with Repeated Measures of Good Readers (N = 40) by the Five English Complement Structures

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of English Complements)	33.07	4	8.27	12.98 ^{***}
S (Subjects)	41.92	39	1.07	
A x S	99.33	156	0.64	
Total	174.32	199		

*** p < .001

Table 47

Summary of a Single-factor Analysis with Repeated Measures
of Poor Readers (N = 43) by the Five English Complement Structures

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of English Complements)	13.19	4	3.30	5.00 ^{***}
S (Subjects)	38.49	42	0.92	
A x S	110.81	168	0.66	
Total	162.49	214		

p < .001

The results from Table 46 indicate that for good readers the between structure variation ($F = 12.98$, $df = 4, 199$) was significant at the .001 level. The results of the Scheffé analyses reveal that Complement 5 was significantly more comprehensible than Complement 3 ($F = 50.43$), Complement 2 ($F = 25.81$) and Complement 4 ($F = 15.41$) (see Appendix U). No significant difference was discerned however between Complements 5 and 1. Complement 3 was significantly more difficult than Complement 1 ($F = 17.76$), Complement 4 ($F = 10.08$) and Complement 5 ($F = 50.43$). No significant difference was observed between Complements 3 and 2.

Table 47 indicates that for poor readers the between structure variation ($F = 5.00$, $df = 4, 214$) was significant at the .001 level. Scheffé multiple comparisons show that Complements 1 and 5 are significantly more comprehensible than Complement 2 (see Appendix U). No significant differences were observed for the other structures.

The graph of Figure 8 compares the comprehensibility levels of the two groups in the five complement structures.

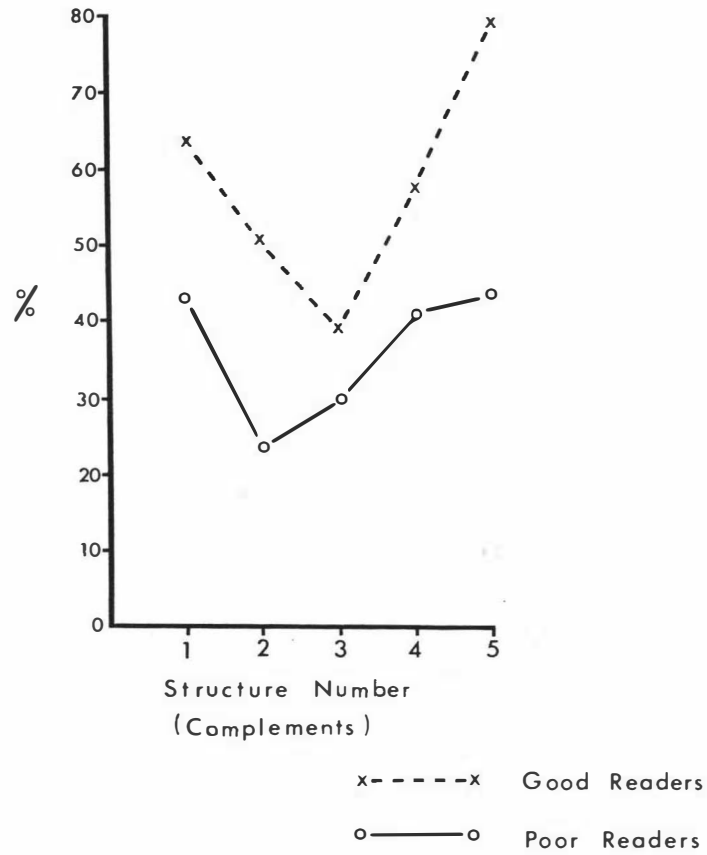


Figure 8: Comprehensibility Levels of the Five English Complement Structures for Good and Poor Readers

Comprehensibility levels of the five English comparative structures for good and poor readers

Table 48 shows good and poor reader comprehension scores, means and standard deviations for each of the five comparative structures.

Table 48

Comprehension Scores, Means and Standard Deviations of the Five Comparative Structures for Good (N = 40) and Poor Readers (N = 43)

Types of Comparative Structures	Raw Scores	Percentage	Mean	SD
<u>Comparison 6</u>				
Good Readers	51	42.5	1.28	.85
Poor Readers	46	35.6	1.07	.83
<u>Comparison 7</u>				
Good Readers	108	90.0	2.70	.52
Poor Readers	62	48.0	1.47	.96
<u>Comparison 8</u>				
Good Readers	59	49.1	1.48	.75
Poor Readers	44	34.1	1.02	.80
<u>Comparison 9</u>				
Good Readers	86	71.6	2.15	.83
Poor Readers	61	47.2	1.42	1.03
<u>Comparison 10</u>				
Good Readers	55	45.8	1.38	.98
Poor Readers	33	25.5	.77	.84

Each comprehension score was derived by adding together the number of correct responses to the appropriate three questions. For good readers, the comprehension raw scores ranged from 108 to 51 (for each comparative structure). The percentage score column shows the percent of correct responses for each comparative structure. The percentages ranged from 90.0 to 42.5. The mean score column shows the average number of items correct for each structure (three items for each structure).

For poor readers, the comprehension raw scores ranged from 62 to 33 (for each comparative structure). Their percentage scores ranged from 48.0 to 25.5.

To test for differences between good and poor readers' levels of comprehensibility of the five comparative structures, the comprehension scores were analyzed separately for each group by means of a single-factor analysis of variance (repeated measures) design (Keppel, 1973). Scheffé multiple comparisons were performed to test for significance of the differences between adjacent means. Both are discussed below.

Single-factor analyses of variance (repeated measures). Single-factor analyses of variance (repeated measures) were calculated on each of the two reading ability groups across the comprehension scores of five comparative structures. The results of the analyses differentiating good and poor readers are presented in Table 49 and 50 respectively.

Table 49

Summary of a Single-factor Analysis with Repeated Measures
of Good Readers (N = 40) by the Five English Comparative Structures

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of English Comparative Structures)	59.77	4	14.94	29.65 ^{***}
S (Subjects)	46.20	39	1.18	
A x S	78.63	156	0.50	
Total	184.60	199		

p < .001

Table 50

Summary of a Single-factor Analysis with Repeated Measures
of Poor Readers (N = 43) by the Five English Comparative Structures

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of English Comparative Structures)	14.63	4	3.66	4.98 ^{***}
S (Subjects)	45.24	42	1.08	
A x S	123.37	168		
Total	183.24	214		

p < .001

Table 49 indicates that for good readers the between structure variation ($F = 29.65$, $df = 4$, 199) was significant at the .001 level. Scheffé multiple comparisons reveal that Comparison 7 was significantly more comprehensible than Comparison 6 ($F = 43.83$), Comparison 8 ($F = 32.36$), and Comparison 10 ($F = 37.88$) (see Appendix U). No significant difference was observed, however, between Comparisons 7 and 9. Comparison 6 was significantly more difficult than Comparison 7 ($F = 43.83$) and Comparison 9 ($F = 16.45$). However no significant differences were found between Comparison 6 and Comparisons 8 and 10.

Table 50 indicates that for poor readers the between structure variation ($F = 4.98$, $df = 4$, 214) was significant at the .001 level. Scheffé multiple comparisons reveal that Comparison 10 is significantly more difficult than Comparison 7 ($F = 16.3$) and Comparison 9 ($F = 14.08$) (see Appendix U). No significant differences were observed for the other structures.

The graph of Figure 9 compares the comprehensibility levels of the two groups in the five comparative structures.

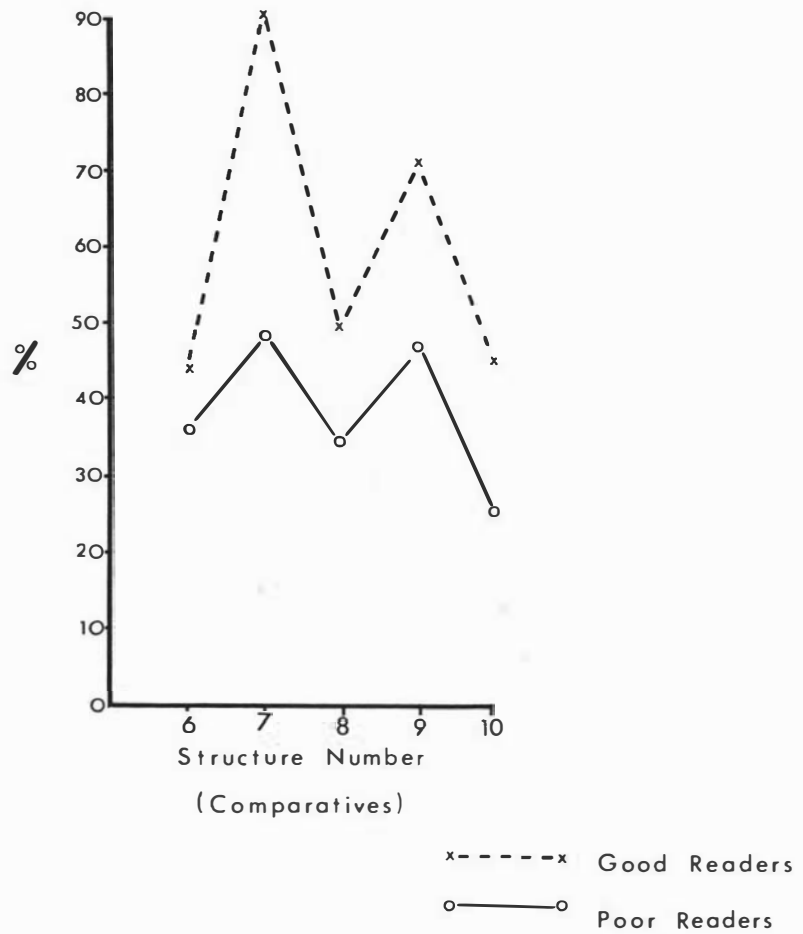


Figure 9: Comprehensibility Levels of the Five English Comparative Structures for Good and Poor Readers

Comprehensibility levels of the five English relative structures for good and poor readers

Table 51 shows the comprehension scores, means and standard deviations for each of the five relative structures -- for good and poor readers.

Table 51

Comprehension Scores, Means and Standard Deviations of the Five
Relative Structures for Good (N = 40) and Poor Readers (N = 43)

Types of Relative Structures	Raw Scores	Percentage	Mean	SD
<u>Relative 11</u>				
Good Readers	80	66.6	2.00	.68
Poor Readers	43	33.3	1.00	.65
<u>Relative 12</u>				
Good Readers	68	56.6	1.70	.82
Poor Readers	46	35.6	1.07	.83
<u>Relative 13</u>				
Good Readers	80	66.6	2.00	.88
Poor Readers	57	44.1	1.33	.81
<u>Relative 14</u>				
Good Readers	91	75.8	2.28	.88
Poor Readers	60	46.5	1.40	.88
<u>Relative 15</u>				
Good Readers	83	69.1	2.08	.76
Poor Readers	60	46.5	1.40	.90

For good readers, comprehension raw scores ranged from 91 to 68 (for each relative structure). Each comprehension score was obtained by adding together the number of correct responses to the appropriate three questions. The percentage score column contains the percent of total correct responses for each structure and derived by dividing the actual obtained correct responses by the possible correct responses (120 per each structure). The mean score column shows the average number of items correct for each structure (three items for each structure).

For poor readers, the comprehension raw scores ranged from 60 to 43, and the percentage scores ranged from 46.5 to 33.3. The mean score column shows the average number of items correct for each structure (three items for each structure).

To determine whether there were any differences in the comprehensibility levels of the five relative structures for good and poor readers, the comprehension scores were analyzed separately for each group by means of a single-factor analysis of variance (repeated measures) (Keppel, 1973). Scheffé multiple comparisons were performed to test for significance of the difference between adjacent means. Both are discussed below.

Single-factor analyses of variance (repeated measures). Single-factor analyses of variance (repeated measures) were calculated on each of the two reading ability groups across the comprehension scores of the five relative structures. The results of the analyses for good and poor readers are presented in Table 52 and 53 respectively.

Table 52

Summary of a Single-factor Analysis with Repeated Measures
of Good Readers (N = 40) by the Five English Relative Structures

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
A (Types of English Relative Structures)	6.83	4	1.71	3.28**
S (Subjects)	45.98	39	1.18	
A x S	81.17	156	0.52	
Total	133.98	199		

**
p < .01

Table 53

Summary of a Single-factor Analysis with Repeated Measures
of Poor Readers (N = 43) by the Five English Relative Structures

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F
A (Types of English Relative Structures)	6.11	4	1.53	2.52*
S (Subjects)	38.90	42	0.93	
A x S	101.89	168	0.61	
Total	146.90	214		

* $p < .05$

Table 52 indicates that for good readers the between structure variation ($F = 3.28$, $df = 4$, 199) was significant at the .01 level. Scheffé multiple comparisons show a significant difference only between Relative 12 and Relative 14 ($F = 12.94$) (see Appendix V).

Table 53 indicates that for poor readers the between structure variation ($F = 2.52$, $df = 4$, 214) was significant at the .05 level. Scheffé multiple comparisons reveal no significant difference in the comprehensibility levels of the relatives for the poor readers (see Appendix U).

The graph in Figure 10 compares the comprehensibility levels of the two groups.

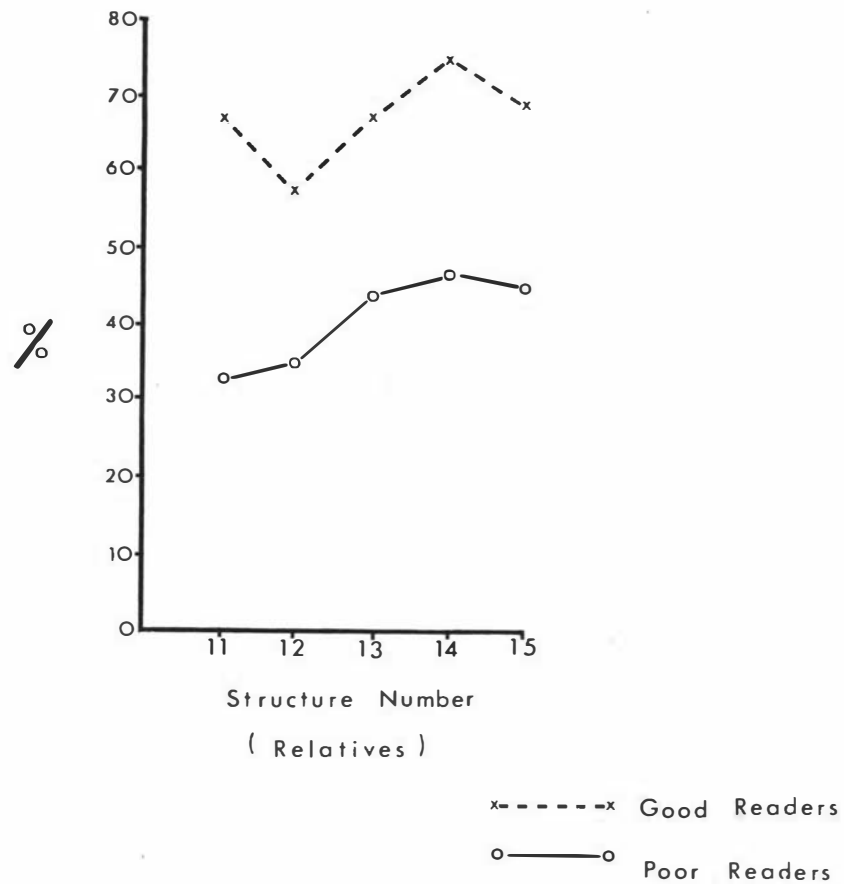


Figure 10: Comprehensibility Levels of the Five English Relative Structures for Good and Poor Readers

Conclusions

For good readers:

- (i) When three types of complex structures (complements, comparatives and relatives) were compared, relatives were found to be significantly more comprehensible than complements ($\underline{F} = 24.38$) and comparatives ($\underline{F} = 7.98$).
- (ii) When structures within a complement type were compared, the results showed that Complement 5 is significantly more comprehensible than Complement 3 ($\underline{F} = 50.43$), Complement 2 ($\underline{F} = 25.81$) and Complement 4 ($\underline{F} = 15.41$). No significant difference was observed, however, between Complements 5 and 1.

Complement 3 was shown to be significantly more difficult than Complement 1 ($\underline{F} = 17.76$), Complement 4 ($\underline{F} = 10.08$) and Complement 5 ($\underline{F} = 50.43$). No signif-

ificant difference was discerned between Complements 3 and 2.

- (iii) When structures within a comparative type were compared, the results revealed that Comparison 7 was significantly more comprehensible than Comparison 6 ($\underline{F} = 43.83$), Comparison 8 ($\underline{F} = 32.36$), and Comparison 10 ($\underline{F} = 37.88$). No significant difference was observed, however, between Comparisons 7 and 9. Comparison 6 was found to be significantly more difficult than Comparison 7 ($\underline{F} = 43.83$) and Comparison 9 ($F = 16.45$). No significant differences were observed between Comparison 6 and Comparison 8, and between Comparison 6 and Comparison 10.
- (iv) When structures within a relative type were compared, the results revealed that there was a significant difference between Relative 12 and Relative 14 ($\underline{F} = 12.94$) only.

For poor readers:

- (i) When three types of complex structures were compared, no significant differences were observed.
- (ii) When structures within a complement type were examined, the results showed that Complement 2 was significantly more difficult than Complement 1 ($\underline{F} = 12.0$) and Complement 5 ($\underline{F} = 12.0$). The differences between Complement 2 and 3, and between Complement 2 and 4, however, were not significant.
- (iii) When structures within a comparative type were compared, the results indicated that Comparison 10 is significantly more difficult than Comparison 7 ($\underline{F} = 16.3$) and Comparison 9 ($\underline{F} = 14.08$). The differences between Comparison 10 and Comparison 6, and between Comparison 10 and Comparison 8, however, were not significant.
- (iv) When structures within a relative type were compared, the results revealed that there was no significant difference between relative structures.

CHAPTER 6

DISCUSSION OF RESULTS

Introduction

Answers to the three main research questions posed in the present study have been reported in the previous chapter. The present chapter is devoted to an interpretation and discussion of the results and to a consideration of their relationship to previous studies. These purposes are to be achieved by discussing first the relationship between the Thai science students' comprehension of English grammatical structures and their reading comprehension of scientific English passages and second the patterns of comprehensibility levels of complement, comparative and relative structures for good and poor readers. An attempt was made to examine whether there are general characteristics which difficult and easy structures respectively have in common across various types of English complex structures. The final section will be devoted to the third research question dealing with differences in the comprehensibility of complex structures. In the process, an attempt will be made to discern why certain structures within any one type were more comprehensible than others by examining whether there are any features which distinguish easy structures from difficult structures. Explanation of the different levels of comprehensibility of English complex structures will be sought, for example, in terms of (i) the presence or absence of surface cues, (ii) the surface elements which are fully or partly presented in surface structures, (iii) word order within clauses, (iv) clause order (main-clause-first or subordinate-clause-first), and (v) the role of the grammatical functions of the identical noun phrases.

Relationship Between Comprehension of English Complex Structures and Reading Comprehension of Scientific English Discourse

The two correlation coefficients obtained between the Test of English Grammatical Structures and (i) the Cloze Reading Comprehension Test ($r = .65$) and (ii) the Multiple-choice Reading Comprehension Test ($r = .66$) imply that the ability of Thai science students to comprehend English complex structures is positively related to their reading comprehension of longer scientific English discourse. The results are

consistent with those obtained by Gibbons (1941), O'Donnell (1963), Sauer (1969) and Shackford (1976) whose subjects were native English speakers, and with those obtained by Charoensook (1974), Chatasingha (1972), Onprapai (1974), Srivicharn (1978) and Thammongkol (1970) whose subjects were native speakers of Thai. The results of the present study with its focus on the reading of scientific English rather than general English and on science students at the university level rather than those at the lower level, seem to provide further support for the notion that comprehending English grammatical structures is important for reading comprehension -- not only of longer passages of general English but also of longer scientific English passages.

The analysis of sex subgroups also deserves comment. The results of the present study produced no statistically significant differences between males and females when means were compared (see Table 32). However a significant male-female difference was found from correlating separately for males and females, the scores from the two tests -- the Test of English Grammatical Structures and the Multiple-choice Reading Comprehension Test. There males were superior to females (see Table 33). This difference though not easy to explain is discussed below, following Simons' (1970) line of argument.

The correlation coefficient between the Test of English Grammatical Structures and the Multiple-choice Reading Comprehension Test was higher for males. This seems to suggest at first glance that ability to comprehend English complex structures might play a more important part in reading comprehension for males than for females. In other words, it implies that males more than females might make use of the knowledge of English complex structures to comprehend scientific English passages. It also implies that males comprehend scientific English passages in conjunction with a better knowledge of English complex structures than do females. Speculation over a possible explanation follows.

The ability to comprehend English complex structures may in fact be a lower level skill than some of the higher level skills that the Multiple-choice Reading Comprehension Test is thought to measure. Since, at the beginning stages of reading, males are usually lower in reading ability than are females (Clark, 1970; Gibson & Levin, 1975; Herman, 1975; Johnson, 1973-74; Malmquist, 1960; Thorndike, 1973), it is

possible that the males may be at a lower stage of reading development than females. At this lower stage, the ability to comprehend English grammatical structures may be more important than at the higher stages.

Though plausible, this speculation can find little other support in the data. The notion that the females are on a higher level and that the males are on a lower level does not seem to hold for the sample studied here. First, no significant differences were found between males and females when means were compared (see Table 32). Second, no significant sex differences were shown in the relationship between the scores from the Test of English Grammatical Structures and the cloze scores.

It appears that the sex differences with the Multiple-choice Reading Comprehension Test criterion may be better explained otherwise, perhaps as a peculiarity of the test, its administration or the sample studied. There is however, no basis for any definitive conclusion.

Relationship Between Good and Poor Reader Comprehension Patterns of English Complex Structures

The high correlation coefficient of $r = .81$ between the pattern of the comprehensibility levels of the 15 English complex structures for good readers and that of the comprehensibility levels of the same structures for poor readers indicates that generally structures are similarly difficult and comprehensible for both good and poor readers. These findings seem to be consistent with those obtained by Bormuth (1966) and Scott (1976) who found that the same features of language influence readability for both good and poor readers. The features of language investigated in the previous studies are, however, different. Scott's study which was involved with the black first graders, investigated 23 English grammatical patterns. Bormuth included in his study such variables as word depth, letter redundancy, independent clause frequency, letter counts, parts of speech, word frequency index, syllable counts, word counts and prepositional phrases. The subjects involved were native speakers of English from the fourth through the eighth grade.

A closer examination of various types of English complex structures grouped under various comprehension categories both for good readers and for poor readers (see Table 40) reveals some interesting points which deserve further comment.

First of all, it is obvious that those structures grouped within the most comprehensible category both for good and poor readers carry particular types of surface cues in the surface structure. That was clearly different from the type of surface cues appearing in the surface structures of the different English complex structures. To illustrate, the surface cues which appear in the structures classified under the most comprehensible category both for good and poor readers include:

- (i) The comparative elements more, less or the bound morpheme -er with the presence of than in comparisons of inequality.
- (ii) The comparative element same used reciprocally, in comparisons of similarity.
- (iii) The relative pronouns which in relative clauses.
- (iv) The relative pronoun which after a preposition in relative clauses.

On the other hand, the surface cues which appear in those structures grouped within the most difficult category for good and for poor readers are:

- (i) The complementizer to in complement structures - Types 2 and 5.
- (ii) The comparative element other used anaphorically in comparison of difference.
- (iii) The comparative element as used as relative -like in comparison of equality.

All of the surface cues which appear in those complex structures grouped within the most comprehensible category share similar characteristics. These cues not only signal the existence of the embedded clauses but also help make explicit the relationship of the embedded clause to the main clause.

The comparative elements more, less or the bound morpheme -er with the presence of than in the surface structure (as in Item 20), not only indicate the existence of the comparison of inequality but also make explicit the pair of comparative clauses:

Item 20: Most materials in the physical world actually require activation energies far greater than those energies provided by ordinary temperatures.

With the presence of than, the comparative pair "activation energies" and "energies provided by ordinary temperatures" is easily identified by the readers.

Similarly, the comparative element same used reciprocally, not only signals the existence of the comparison of similarity, but also provides a clue to a reader to look for a comparison which is "internal", as in Item 22 below:

Item 22: The two spatial arrangements represent two different configurational isomers of the same molecular formula.

The comparative element same signals the comparative constituents in the surface structure. A reader is directed to look for a comparison where "two different configurational isomers of the same molecular formula are compared with each other".

The relative pronouns which and which after a preposition mark the existence of the relative clauses, provide clues to a reader as to which noun phrase antecedent the clause is qualifying and which function it holds in the relative clause. Consider the following two sentences:

Item 19: Atmospheric oxygen is the source of the ozone (O_3) layer which envelops the earth at an altitude of some 10 miles.

Item 40: The various orbitals in which the electrons of an isolated atom may be found are called atomic orbitals.

In Item 19, the relative pronoun which indicates that a sentence "the ozone layer envelops the earth..." has been embedded into the larger sentence as relative clause. It also indicates that the antecedent noun phrase is "ozone layer" and that it functions as the subject of the embedded clause.

In Item 40, the relative pronoun which after the preposition in marks the appearance of the embedded clause "in which the electrons of an isolated atom may be found", and provides a clue to a reader that the antecedent noun phrase which is "orbitals" functions as a complement after a preposition in the relative clause, "the electrons of an isolated atom may be found in the various orbitals".

Consider another group of surface cues appearing in complex structures grouped under the most difficult category. These surface cues are found to increase sentence ambiguity rather than help the readers identify the embedded constituents. The complementizers to in Item 7, and 42, for example, introduces the complement structures not in the form of clauses but in the form of infinitival phrases.

Item 7: "These three features will be seen to be
the chief features of the halogenation
reaction"

Item 42: "Nowadays chemists wish to devise
syntheses of exotic molecules
found in nature"

Here, the complementizer to in both sentences does not signal the presence of the embedded clauses. Moreover, it does not help identify the subject noun phrase of the clause.

The comparative element other used anaphorically requires a reader to identify what has been mentioned earlier in order to be able to make a comparison of difference, as shown in Item 45:

Item 45: There are a number of other reactions
of acid derivatives that also involve
initial nucleophilic attack on the
carbonyl group.

A reader is required to discover that "some reactions of acid derivatives" have been mentioned earlier in order to understand the above sentence.

The comparative element as with the relative clause characteristics, marks the comparative clause of equality. However as does

not help the reader identify the comparative pair, as seen in Item 6:

Item 6: Cenozoic climates played a major role
in plant evolution, as noted earlier.

What is compared is not the immediate antecedent noun phrase "plant evolution" but the whole clause "Cenozoic climates played a major role in plant evolution".

To conclude, it seems that one general feature which is shared by those complex structures classified under the most comprehensible category is the type of surface cue which makes explicit the embedded clauses in the surface structure. Those complex structures grouped under the most difficult category seem to carry another type of surface cue which does not help make explicit the embedded clauses but seems to make the sentences more ambiguous.

Another general feature shared by easy structures seems to be that all surface elements are present and that there is a tendency for the order of surface elements within clauses not to be changed. In the difficult structures, on the other hand, not all surface elements are present. The reader has to search for them elsewhere.

Comprehensibility Levels of Complex Structures for Good and Poor Readers

The findings on the differences within (i) three main types of complex structures, (ii) five manifestations of complements, (iii) five types of comparisons, and (iv) five types of relative structures, which were reported in Chapter 5 are relevant to the discussion in this section.

Under each heading, attention will be given first to good readers and poor readers separately and then to a comparison between them with respect to their comprehension of complex structures.

Comprehensibility levels of the three main types of complex structures

Good readers. The analysis of variance of good readers' scores for the three main types of complex structures implied that the presence of complements, comparatives and relatives in English sentences had different effects on the comprehensibility of English sentences. Sentences containing the relative clause were found to be the easiest.

This result is consistent with the findings obtained by Perkins and Yorio (1974) who reported that non-native English speakers at the advanced level had no difficulty in comprehending English relative sentences.

Poor readers. The results of the analysis of variance of the three types of complex structures indicated that for poor readers the presence of complements, comparatives and relatives had no differential effect on the comprehensibility of English sentences. An examination of the percentage scores of complements (36.1%), comparatives (38.1%) and relatives (41.2%) (see Table 42) reveal that complex structures are all difficult for poor readers to comprehend.

Good readers vs poor readers. Table 54 presents means and standard deviations for complex structure scores for good and poor readers. Statistically significant differences between the two groups are noticeable in all three types of complex structures. These findings indicate, though not surprisingly, that English complement, comparative and relative sentences are more difficult for poor readers to comprehend than for good readers.

Table 54

Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on Three Types of Complex Structures

	Good Readers		Poor Readers		t-Ratio	Probability
	Mean	SD	Mean	SD		
Complements	8.60	2.32	5.42	2.14	6.50	.000
Comparatives	8.98	2.43	5.74	2.32	6.19	.000
Relatives	10.05	2.43	6.19	2.15	7.68	.000

In the following sections, an attempt will be made further to find out whether certain complex structures within a given type are more comprehensible than others for good and poor readers and why they are so.

Comprehensibility levels of the five complement structures

The five types of complement structures to be discussed in the present section are as follows:

Complement 2

Item 7: These three features will be seen to be the chief features of the halogenation reaction.

Complement 3

Item 42: Nowadays chemists wish to devise syntheses of exotic molecules found in nature.

Complement 5

Item 9: By moving the resonator along the line PQ, Hertz found the position of the nodes and antinodes and the direction of the magnetic field.

Complement 1

Item 24: The minus sign indicates that the net flow (mass transport) is in the direction in which n (the concentration of the substance) decreases.

Complement 4

Item 5: The fact that an electric current produces a magnetic field suggests that a single moving charge must also produce a magnetic field.

Good readers. An examination of the means of each of the five complement structures reveals that among the non-finite complements (Complement numbers 2, 3, 5), Complement 3 (as in Item 42) and Complement 2 (as in Item 7) significantly affected the comprehensibility of English sentences for good readers. The results in Table 55 reveal that both Complement 2 (50% of the responses were correct) and Complement 3 (38.3%) are difficult for good readers. Complement 5 (79.1%) is the most comprehensible of the non-finite complements.

Table 55

Complement Structure Comprehension Scores
and Percentages: Good and Poor Readers

	Good Readers			Poor Readers		
	N	No. of Responses (Tot. = 120)	%	N	No. of Responses (Tot. = 129)	%
<u>Non-finite Complements</u>						
Complement 2	40	60	50.0	43	30	23.2
Complement 3	40	46	38.3	43	38	29.4
Complement 5	40	95	79.1	43	56	43.4
<u>Finite Complements</u>						
Complement 1	40	75	63.3	43	56	43.4
Complement 4	40	68	56.6	43	53	41.0

To answer correctly Items 7 and 42 which represent Complements 2 and 3 respectively, a subject has to be able to (i) recognize the embedded clause which comes to the surface structure as an infinitival phrase, and (ii) identify the subject noun phrase of the embedded clause.

In Item 42, for example, good readers failed to recognize that the "to-infinitival phrase", ("to devise syntheses of exotic molecules found in nature"), is an embedded clause -- "chemists devise syntheses of exotic molecules found in nature". Accordingly they chose "chemists wish that exotic molecules are found in nature" as the correct interpretation of the test sentence. An examination of the mistakes which good readers made in translating the same test sentence into Thai reveals similar findings. They translated "chemists devise syntheses of exotic molecules" as "chemists synthesize exotic molecules". It seems that good readers could identify the main clause "Chemists wish that...", however, they could not see that the noun phrase "chemists" which was the subject noun phrase of the main clause was also the subject noun phrase of the

embedded clause -- "chemists devise....". It may be because of the absence of the subject noun phrase of the embedded clause "chemists" which makes this structure difficult to comprehend.

The "to-infinitival phrase" also appeared in Item 7 representing Complement 2. Good readers, again, had difficulty in identifying it. They chose "These three features will be seen in addition to the chief features of the halogenation reaction" as the correct interpretation. Choosing this answer seems to indicate that good readers, while recognizing "(We) will see (that)....." as the main clause, failed to see "These three features are the chief features of the halogenation reaction", as the embedded clause. It was shown that good readers who did not comprehend this structure did not realize that the subject noun phrase of the embedded clause appeared at the front of the sentence. Therefore, instead of seeing the embedded clause as: "These three features are the chief features of the halogenation reaction", they interpreted the embedded clause as "(We) will see the chief features of the halogenation reaction". The mistakes appearing in translation data also support the above findings. Seventy-percent of all the mistakes good readers made in translating this sentence showed the lack of ability to recognize an infinitival phrase as an embedded clause.

An examination of the means of the finite complements investigated in the present study reveals that no significant difference was observed between Complements 1 and 4 (as in Items 24 & 5 respectively). This implies that Complement 4 (56.6% of the responses correct) was not significantly more difficult for good readers than was Complement 1 (63.3%). The findings that both of Complements 1 and 4 are comprehensible for good readers gives support to the statements made earlier by Eskey (1975) and Schmierer (1979). According to Eskey, "factive nominals" (represented by the finite complements investigated in the present study) "are syntactically the simplest kinds of nominalized sentences". For Schmierer (1979), "embedded statements", (which refer to the finite complements) "possess least linguistic complexity; since their construction requires no structural change to be made in the statement to be embedded". A further examination of the sentences in Items 24 and 5 reveals that both sentences carry the complementizer that. As found in Hakes' (1972) study, the presence of the complementizer that seems to

have an effect on the comprehensibility of complement sentences. Similar effects were discerned in the present study. The data here reveal that for good readers, the finite complements 1 and 4 (as in Items 24 & 5) were significantly more comprehensible than was the non-finite complement 3 (as in Item 42). The difficulty associated with Complement 3 might be due to the effect of the complementizer to which introduces an infinitival phrase as an embedded clause. Alternatively, it might be due to the fact that a subject noun phrase of the "to-infinitival phrase" is deleted.

Poor readers. Poor readers' comprehension scores for the five complement structures reveal that among the non-finite complements (Complements 2, 3, 5), the presence of Complement 2 (as in Item 7) affected comprehensibility of English sentences significantly more than did the presence of Complement 5) (as in Item 9). The percentages of correct responses for Complement 2 and 5 were 23.2 and 43.4 respectively. This shows that poor readers have difficulty in comprehending even Complement 5 (43.4%). Their comprehension of Complement 2 is very limited (23.2%). Based on the item analysis data, 45% of the mistakes made by poor readers derived from the inability to see the to-infinitival phrase.

Similar to the findings for good readers, the finite complements (Complements 1 & 4) were not significantly different for poor readers. The percentage of the correct responses were 43.4 and 41.0 respectively. These findings indicate that both Complements 1 and 4 are difficult for the poor readers. The data reveal further that Complement 1 (as in Item 24) was significantly more comprehensible than Complement 2 (as in Item 7). This finding gives rise to some interesting points. Firstly, it indicates that for poor readers the presence of the complementizer that tends to increase sentence comprehension whereas the presence of the complementizer to tends to decrease it. Secondly, the fact that the subject noun phrase of the main clause was absent whereas the subject noun phrase of the embedded clause appeared at the beginning of the sentence tends to affect poor readers' sentence comprehension as seen in Item 9. On the other hand, the presence of a subject-verb-object order in the embedded clause as in Item 24 tends to increase sentence comprehension.

Good readers vs poor readers. Statistically significant differences between good and poor readers' comprehension scores were discerned in the cases of Complements 1, 2, 4 and 5 (see Table 56). These significant differences indicate, not surprisingly, that good readers performed better than poor readers on the items which measure Complements 1, 2, 4 and 5. As revealed from item analysis data, the types of mistakes made by poor readers were similar to those which good readers made. Poor readers however made more. Discussion follows.

(i) To answer correctly those items which measure finite complement structures (Complements 1 & 4 as in Items 24 & 5 respectively), a reader is required to recognize the complementizer that which brings forth on the surface structures the appearance of the embedded clause. A reader also needs to know that complement clauses can occur either as a subject or an object of the main clause. Both good and poor readers of the present study seem to recognize the presence of the complementizer that. Both groups however failed to see that an embedded clause is a subject of the main clause (as seen in Item 5). They also failed to see that the embedded clause in Item 24 was an object of the main clause. Accordingly, both groups thought, for example, that either (i) "the minus sign indicates the net flow", or (ii) "the minus sign indicates the decrease of the concentration of the substance" was the correct kernel sentence of the test sentence of Item 24. In the case of the subject complement, both groups thought that, "An electric current suggests that a single moving charge must also produce a magnetic field", was the correct kernel sentence of the test sentence in Item 5.

Table 56

Means, Standard Deviations and t-test Results for Good (N = 40)
and Poor Readers (N = 43) on the Five Complement Structures

	Good Readers		Poor Readers		t-Ratio	Probability
	Mean	SD	Mean	SD		
<u>Non-finite</u>						
<u>Complements</u>						
Complement 2	1.50	0.85	0.70	0.86	4.28	.000
Complement 3	1.15	0.86	0.88	0.76	1.49	.140 N.S.
Complement 5	2.38	0.84	1.30	0.89	5.65	.000
<u>Finite</u>						
<u>Complements</u>						
Complement 1	1.88	0.79	1.30	0.80	3.27	.002
Complement 4	1.70	0.91	1.23	0.90	2.36	.021

Another mistake poor readers made was that the correct interpretation of the test sentence in Item 5 was "A magnetic field suggests that a single moving charge must also produce a magnetic field". This type of mistake produced only by poor readers, showed that poor readers depended very much on the surface structure. They seemed to take a noun immediately preceding a verb as the subject of that verb. This general rule however cannot be applied to this structure.

(ii) As stated earlier, Complement 5 seems not to have caused difficulty to good readers (see Table 55). This structure however seems to have been difficult for poor readers (66.6% of the responses were incorrect). To answer correctly for example Item 9 which measures the structure, a reader is required to see the relationship between a main clause and an embedded clause. For Item 9, a reader needs to be able to identify "Hertz" as the subject of "moving". Those poor readers who failed to understand this structure chose the following sentence as a correct interpretation, "Hertz found the position of nodes and anti-nodes because the resonator moved the direction of the magnetic field".

(iii) For Complement 2, both good and poor readers again made similar types of mistakes. Both groups of readers showed that they are unable to identify the subject noun phrase of the embedded clause which appeared on the surface structure in the form of a to-infinitival phrase. Accordingly, they thought that, "These three features will be seen in addition to the chief features of the halogenation reaction", was a correct interpretation of the test sentence in Item 7.

So far it has been pointed out that a pattern of mistakes which good and poor readers made on four types of complements (Complements 1, 2, 4 & 5) is similar. The difference between the two resides in the higher number of mistakes made by poor readers. T-test results provided evidence of the difference.

Good and poor readers' comprehension scores for Complement 3, however, were similar. This non-significant result implies that good readers do not comprehend this structure any better than poor readers. The percentages of the correct responses made by good and poor readers (38.3 and 29.4 respectively), indicate the difficulty of the structure for both groups. Subsequent item analyses revealed that good readers were unable to identify that the verb "wish" of the main clause in Item 42, for example, and the to-infinitive "to devise" of the embedded clause had an identical subject noun phrase "chemists". Accordingly, both good and poor readers took no notice of either the main verb "wish" or the to-infinitive "to devise". They thought for example that either (i) chemists wish that exotic molecules are found in nature, or (ii) chemists devised exotic molecules found in nature, were correct interpretations of the test sentence.

Comprehensibility levels of the five comparative structures

The five types of comparative structures to be discussed in this section are illustrated below:

Comparison 6

Item 10: In cosmic radiation there are electromagnetic waves of even shorter wavelengths.

Comparison 7

Item 34: The energy levels of an atom with several electrons are much more complex than those of atoms with one electron.

Comparison 8

Item 45: There are a number of other reactions of acid derivatives that also involve initial nucleophilic attack on the carbonyl group.

Comparison 9

Item 22: The two spatial arrangements represent two different configurational isomers of the same molecular formula.

Comparison 10

Item 6: Cenozoic climates played a major role in plant evolution, as noted earlier.

Good readers. Table 57 shows that 90% of the good readers' answers to the three items measuring Comparison 7 were correct whereas, only 42.5% of their answers were correct for Comparison 6. The obtained high percentage scores for Comparison 7 may indicate the effect of the presence of than which introduces the comparative pair on the surface structure. As seen in Item 34, the compatible compared constituents -- "the energy levels of an atom with several atoms" and "the energy levels of atoms with one electron" appear in the surface structure. In terms of complexity, the subject variable "the energy levels of an atom with several electrons" compares with "the energy levels of atoms with one electron". The comparative expansion is easily identified as it is signalled by than. Good readers, however, found Comparison 6 very difficult to comprehend. The difficulty of this structure may partly be due to the absence of than and the consequential deletion of the comparative pair from the surface structure. To understand this structure, a subject has to be able to identify the comparative elements, the identical quantifier elements and the compatible compared constituents. For example, to understand this structure (as in Item 10), a subject has to recognize the bound morpheme -er in the word "shorter" as the signal of the comparison of inequality. Next he has to be able to identify that "the wavelength of the electromagnetic waves in cosmic radiation" is compared with "the wavelength of

Table 57

Comparative Structure Comprehension Scores and Percentages:
Good and Poor Readers

	Good Readers			Poor Readers		
	N	No. of Responses (Tot. = 120)	%	N	No. of Responses (Tot. = 129)	%
<u>Comparisons of Inequality</u>						
Comparison 6	40	51	42.5	43	46	35.6
Comparison 7	40	108	90.0	43	62	48.0
<u>Comparisons of Similarity and Difference</u>						
Comparison 8	40	59	49.1	43	44	34.1
Comparison 9	40	86	71.6	43	61	47.2
<u>Comparisons of Equality</u>						
Comparison 10	40	55	45.8	43	34	25.5

the electromagnetic waves in another kind of radiation" in terms of the length. Good readers who failed to comprehend the item thought that both of the wavelengths of the electromagnetic waves in cosmic radiation and in the other kind of radiation are equally short.

Statistically significant difference was also obtained between Comparison 8 (as in Item 45) and Comparison 9 (as in Item 22). The comparative element same as seen in Item 22 is the one which has reciprocal reference. This means that the comparison of two or more events or objects is purely "internal" (Lee, 1976). The adjectival form of same implies that two different configurational isomers all have the same molecular formula as each other. It may be because the comparative element same used reciprocally makes explicit the pair of the comparative

constituents, that the sentences are more comprehensible for good readers in contrast with sentences with the comparative element other used anaphorically. In the latter, a subject has to identify what has been mentioned earlier in order to make a comparison of difference. The comparative element other in Item 45, for example, shows that some reactions of acid derivatives have been discussed earlier and that there are a number of reactions of acid derivatives other than those mentioned earlier, that also involve initial nucleophilic attack on the carbonyl group. Fifty-eight percent of all the mistakes made by good readers appeared to result from the inability to identify that "some reactions of acid derivatives" had been discussed earlier.

Comparison of equality (Comparison 10 as in Item 6) was also investigated in the present study. Table 57 shows that 45.8% of the responses were correct for this structure. To comprehend Item 6, a subject has to recognize the comparative clause introduced by as, e.g. "as noted earlier". "As noted earlier" behaves like the non-restrictive relative clause "which is noted earlier". A reader has to be able also to identify the antecedent of the comparative clause. In this case, the antecedent of the comparative clause is "Cenozoic climates played a major role in plant evolution". Fifty-eight percent of good readers who failed this item thought that "what was noted earlier" was "plant evolution".

A comparison of the cell means of each of the comparative structures shows that Comparison 10 is significantly more difficult for good readers than Comparisons 7 and 9. The comprehensibility of the easier structures (Comparisons 7 & 9) seem to be due to the signals contained in the comparative elements. With the comparative elements more/ less/-er with the presence of than, and same used reciprocally, present, the comparative pairs can be easily identified in the surface structure. Moreover, the comprehensibility of these easier structures seems to be due to the fact that all information is contained in the surface structure and there is no need to refer elsewhere. The presence of more-than in Item 34, for example, does not only provide the clue to the reader for the existence of the comparison of inequality (Comparison 7) but also make the reader aware of the appearance of the comparative expansion. Similarly, the presence of the comparative element same used reciprocally (as in Item 22) helps make comparison between similarities explicit. What is then required from the reader is only the identification of the

two or more events or objects which appear in the surface structure. On the other hand, the comparative element as, (as in Item 6), which precedes the comparative clause "as noted earlier", does not provide any clue to help a reader discover the appropriate antecedent of the comparative clause. Moreover, it appears to confuse readers over which comparative pair is equal.

Poor readers. Comprehension scores of the comparative structures indicate Comparison 10 to be significantly more difficult for poor readers than Comparison 7 and 9. No significant differences however were obtained between (i) two types of comparisons of inequality (Comparison 6 & 7), and (ii) comparison of difference (Comparison 8) and comparison of similarity (Comparison 9).

Of the poor readers' answers to the three items measuring Comparison 10, only 26.5 percent were correct. The type of mistake poor readers made most was failure to identify the antecedent of the comparative clause. For example, 56 percent of poor readers who answered Item 6, incorrectly, thought that "what was noted earlier" was "plant evolution".

Similar to the findings found for good readers, Comparisons 7 and 9 were significantly more comprehensible than Comparison 10. This difference again may be partly explained by the role of comparative elements. The comparative elements more less/-er, provided than is present, (Comparison 7) and the comparative element same used reciprocally (Comparison 9) both seem to help make explicit the comparative pairs. By contrast, the comparative element as (Comparison 10) did not provide a clue which will help a reader discover the appropriate antecedent of the comparative clause. Rather it seemed to confuse the reader over which comparative pair was equal.

The failure to obtain significant differences between (i) Comparisons 6 and 7 and (ii) Comparisons 8 and 9 reflect two important points. First, explanation may reside in the difficulty of the test items for poor readers. Accordingly, they could not measure well poor readers' comprehension of the structures. Second, it may be due to the construction of the test items. A closer examination of the test sentence reveals, for example, that two of the three items measuring comparison of inequality (Comparison 7) contain a relative clause. The presence of the relative clause might

affect sentence comprehensibility for poor readers. The comprehension scores of this comparative sentence may reflect poor readers' comprehension of comparison of inequality as well as their comprehension of relative structure.

The fact that there was a significant effect of (i) the comparative elements more/less/-er with the presence of than (Comparison 7) and (ii) the comparative element same, on sentence comprehensibility for good readers but a non-significant effect for poor readers could be explained as follows. Usually poor readers are likely to be misled by a wider range of language features than good readers. The mistakes made by poor readers are likely to be more random than those of good readers because poor readers rely more heavily on the surface structure than good readers do. Good readers should show more regular patterns of difficulty because they are subject to a narrower range of difficulties.

Good readers vs poor readers. Statistically significant differences were obtained between good and poor readers' comprehension scores of Comparisons 7, 8, 9 and 10 (see Table 58). They indicate, though not surprisingly, that good readers comprehend these four types of comparison better than poor readers do. Item analysis data reveal that good and poor readers again made similar types of mistakes; poor readers obviously made more. Discussion follows.

(i) As seen in Table 57, Comparison 7 seemed to cause no difficulty for good readers (90% of the responses were correct) whereas it seems to have been difficult for poor readers (only 48% of the responses were correct). An inspection of the type of mistake made by poor readers with the comparative sentences where than is present in the surface structure (Comparison 7) as in Item 34, indicates their lack of ability to identify the compatible compared constituents. Poor readers were more confused than good readers when faced with the comparative sentence where than is present and where not all language elements are explicitly stated in the surface structure. In Item 34, for example, poor readers thought that "an atom with several electrons" and "atoms with one electron" were the compatible compared constituents instead of "the energy levels of an atom with several electrons" being compared to "the energy levels of atoms with one electron". This seems to be partly due to the fact that the language element "those" in the sentence requires poor readers to have a knowledge of anaphoric reference in order to

comprehend fully the compatible compared constituents. The sentence might be easier for poor readers if it were presented as follows:

The energy levels of an atom with several electrons are much more complex than the energy levels of atoms with one electron.

(ii) Table 57 also indicates that the Comparison of Similarity (Comparison 9) as in Item 22 was comprehensible for good readers (71.6% correct) whereas it was difficult for poor readers (47.2% correct). A major type of mistake poor readers made seems to result from inability to identify the pair of comparative constituents, signalled by the comparative element same. For example, they identified "two spatial arrangements" as being compared to "two different configurational isomers"(in Item 22).

(iii) The comprehension scores of good readers on Comparison 8 were 49.1 percent correct (see Table 57). Much lower scores were obtained by the poor readers (34.1% correct). A common type of mistake both groups made was failure to identify information given implicitly. For example, when they were asked to explain the meaning of "other reactions of acid derivatives..." in Item 45, both groups interpreted the sentence as "there are only reactions of acid derivatives that involve initial nucleophilic attack on the carbonyl group". It shows that the subjects seemed to take no notice of the presence of the comparative element other. To answer Item 45 correctly, a reader is required to recognize the comparative element other and realize that there is some implicit information. In case of the sentence in Item 45, a reader needs to know that "some reactions of acid derivatives that involve initial nucleophilic attack on the carbonyl group" have been mentioned earlier in order to have full understanding of the sentence.

(iv) Good and poor readers' comprehension scores of Comparison 10 presented in Table 57 (45.8% & 25.5%) imply that this structure tends to be difficult for good readers and much more difficult for poor readers. Similar types of mistakes were made by both groups. They seem to be confused as to which comparative pair in the sentence was equal. Both groups identified for example that either "plant evolution" or "cenozoic climates" was the appropriate antecedent of the comparative clause "as noted earlier". Again, to obtain the correct meaning of

Item 6, a reader is required to know that the comparative element as possesses relative-like characteristics and that an appropriate antecedent is not the noun phrase preceding the comparative clause but the whole main clause.

Table 58

Means, Standard Deviations and t-test Results for Good (N = 40) and Poor Readers (N = 43) on the Five Comparative Structures

	<u>Good Readers</u>		<u>Poor Readers</u>		t-Ratio	Probability
	Mean	SD	Mean	SD		
<u>Comparisons of Inequality</u>						
Comparison 6	1.28	0.85	1.07	0.83	1.12	.268 N.S.
Comparison 7	2.70	0.52	1.47	0.96	7.37	.000
<u>Comparisons of Similarity and Difference</u>						
Comparison 8	1.48	0.75	1.02	0.80	2.65	.010
Comparison 9	2.15	0.83	1.42	1.03	3.54	.001
<u>Comparison of Equality</u>						
Comparison 10	1.38	0.98	0.77	0.84	3.04	.003

The t-test results in Table 58 indicate further that there was no significant difference between good and poor readers on another type of comparison -- Comparison 6. The lower percentages obtained by both groups (42.5% for good readers and 35.6% for poor readers) for this structure reveal the difficulty level of the structure. Item analysis data have shown that both good and poor readers seem to be unaware of the existence of the comparative structure of inequality. As seen in Item 10, both groups chose as the correct interpretation of the test

sentence the following sequence of words, "the wavelengths of electromagnetic waves in cosmic radiation and those in the other kinds of radiation are equally short". This indicated that both groups did not recognize the bound morpheme -er in the word "shorter" as the signal of the comparison of inequality. Accordingly, they failed to make a comparison between the compatible compared constituents.

Comprehensibility levels of the five relative structures

The five types of relative structures to be discussed in this section are illustrated in the following sentences:

Relative 11

- Item 17: Each carbon of the C=C is converted to a C=O, and any hydrogen attached to these particular carbons is converted to an -OH group.
- Item 38: A fungus is covered by a rigid wall composed of cellulose in primitive types.

Relative 12

- Item 8: The magnetic field at points inside a cylinder carrying a current on its surface is zero.
- Item 35: The intramolecular aldol type of condensation is very valuable as a cyclization reaction leading to the formation of five- and six-membered rings.

Relative 13

- Item 36: Many multicellular organisms have highly specialized sensory cells that are exceedingly sensitive and respond to even weak stimuli.
- Item 41: A carbon atom that employs this set of orbitals for bonding is said to have sp^2 hybridization.

Relative 14

- Item 12: Many substances which normally are isotropic become anisotropic when subject to mechanical stresses or to strong static electric or magnetic fields.

Item 19: Atmospheric oxygen is the source of the ozone(O_3) layer which envelops the earth at an altitude of some 10 miles.

Relative 15

Item 40: The various orbitals in which the electrons of an isolated atom may be found are called atomic orbitals.

Item 14: Because of the negative sign in Equation (16.18), the electric field points in the direction in which the electric potential decreases.

Good readers. Table 59 shows that 75.8 percent of the good readers' answers to the three items measuring Relative 14 were correct whereas 56.6 percent of their answers were correct for Relative 12.

The significant effect of Relative 14 on sentence comprehensibility may partly be explained by (i) the presence of the relative pronoun which, (ii) the effect of the coreferential noun phrases which have the same grammatical function, and (iii) the position of the relative clause. All these are discussed further below.

Table 59

Relative Structure Comprehension Scores and Percentages:
Good and Poor Readers

	Good Readers			Poor Readers		
	N	No. of Responses (Tot. = 120)	%	N	No. of Responses (Tot. = 129)	%
<u>Non-finite</u>						
<u>Relatives</u>						
Relative 11	40	80	66.6	43	43	33.3
Relative 12	40	68	56.6	43	46	35.6
<u>Finite</u>						
<u>Relatives</u>						
Relative 13	40	80	66.6	43	57	44.1
Relative 14	40	91	75.8	43	60	46.5
Relative 15	40	83	69.1	43	59	45.7

(i) It is obvious that in all three items measuring Relative 14 (Items 12, 19, 30), the relative clauses are signalled by the relative pronoun which, whereas in the other three items measuring Relative 12 (Items 4, 8, 35), relative pronouns are absent from the surface structure. The relative pronoun which in Item 19, for example, helps the reader identify the relative clause, "which envelops the earth at an altitude of some 10 miles". Further the reader is directed to its noun antecedent "ozone layer" which in this case becomes a subject of the relative clause -- "the ozone layer envelops the earth at an altitude of some 10 miles". On the other hand, the absence of the relative pronoun in Relative 12 (as in Item 8) seems to increase sentence difficulty because no clue is available in the surface structure to signal the presence of a relative clause. The findings of the present study seem to give support to the findings of previous studies which reported that relative clauses where relative pronouns are present in the surface structure are easier to understand than the reduced

relative clauses -- the clauses where the relative pronouns are deleted from the surface structure (Fodor & Garrett, 1967; Hakes & Cairns, 1970).

(ii) The greater percentage of correct answers for Relative 14 (75.8%) may also be partly due to the effect of the grammatical functions of the identical noun phrases in relative sentences. Sheldon (1974), who investigated children's comprehension of relative clauses, tested what she called the "Parallel Function Hypothesis" which claims that children will be following a strategy of interpreting the grammatical function of the relative pronoun as being the same as its antecedent. Following this hypothesis, Sheldon hypothesised further that those sentences in which the shared nominals have the same grammatical function in their respective clauses (for example, in "The man saw the boy who the girl hit" -- where the shared nominal "the boy" functions as object of the main clause and object of the embedded clause) will be easier to process than sentences in which the coreferential noun phrases have different grammatical functions, (for example, in "The man saw the boy who hit the girl" -- where the shared nominal "the boy" functions as object of the main clause but subject of the embedded clause). Sheldon found in her study that "performance on parallel function relative sentences in which the identical noun phrases have the same grammatical function is better than performance on non-parallel function sentences". In the present study, two of the three items measuring subject relative clauses preceded by which (Relative 14) as in Items 12 and 30 have the coreferential noun phrases which have the same grammatical function in their respective clauses. For example, the shared nominal "substances" from Item 12 functions as the subject of the main clause and the subject of the relative clause. On the other hand, in two of the three items measuring subject relative clauses preceded by participial -ing (Relative 12) as in Items 4 and 8, the coreferential noun phrases have different grammatical functions. To illustrate, the shared nominal "cylinder" in Item 8 functions as an object after a preposition in the main clause but as a subject of the embedded clause.

(iii) The position of a relative clause may also partly explain the higher percentage of correct answers for Relative 14. According to Miller and his co-workers (Miller & Chomsky, 1963; Miller & Isard, 1964), a relative clause which is placed in the centre of a sentence,

modifies the subject of the clause that dominates it, separating the subject of that clause from the predicate. On the other hand, a relative clause which is right-branching, modifies the object of the dominating clause and occurs after that clause's predicate. To illustrate, the relative clause, "which envelops the earth at an altitude of some 10 miles" in Item 19, is considered right-branching, whereas the relative clause "which normally are isotropic" in Item 12, is considered centre-embedded. Previous studies on the comprehensibility of relative sentences have shown that centre-embedded relative clauses are more difficult to process than right-branching relative clauses (Blumenthal, 1966; Miller & Chomsky, 1963; Miller & Isard, 1964; Stolz, 1967).

In the present study, two of the three items measuring Relative 14 (Items 19 & 30) which appears to have been more comprehensible than Relative 12, contain right-branching relative clauses, whereas two of the other three items measuring Relative 12 (Items 4 & 8) contain centre-embedded relative clauses.

The analyses of each of the relative structures also show that: there were no significant differences between (i) two types of non-finite relatives -- Relative 11 (as in Item 17) and Relative 12 (as in Item 8) or (ii) among three types of finite-relatives -- Relative 13 (as in Item 41), Relative 14 (as in Item 12) and Relative 15 (as in Item 40). The non-significant effect between Relative 11 and Relative 12 may partly be due to (i) absence of relative pronouns in the surface structure and (ii) position of relative clauses.

In all test sentences measuring Relative 11 and Relative 12, relative pronouns and copulas are absent from the surface structure. Relative clauses, as in Items 17, 32, 38, are preceded by participial -ed/-en. Those in Items 4, 8, 35 are preceded by participial -ing. To comprehend these structures, a reader is required to know what elements have been reduced and which noun phrase is modified by the reduced clause. Good readers who failed to comprehend a relative sentence where the relative clause is preceded by -ing, for example, thought that the following sequence of words, "the magnetic field inside a cylinder carries a current on its surface", was a kernel sentence of the test sentence in Item 8. A similar type of mistake was found when good readers failed to comprehend a relative sentence

where the relative clause was preceded by -ed/-en. They thought, for example, that the following sequence of words, "these particular carbons are converted to an -OH group", was a kernel sentence of the test sentence in Item 17.

Centre-embedded relative clauses may partly contribute to the difficulty of relative sentences. In the present study, two items which measure Relative 12 (Items 4 & 8) and the other two items which measure Relative 11 (Items 17 & 32) carry centre-embedded relative clauses.

The fact that no significant differences were observed among three types of finite relatives (Relatives 13, 14, 15) reveals that Relative 13 (where 66.6% of the responses were correct), Relative 14 (where 75.8% were correct) and Relative 15 (where 69.1% were correct) are all reasonably comprehensible for good readers. This may partly be explained by the common presence of the relative pronouns which and that in the surface structure. In all three items measuring Relative 13 (Items 2, 36, 41) for example, the relative clauses are signalled by the relative pronoun that. In those three items measuring Relative 14 (Items 12, 19, 30) the relative clauses are signalled by the relative pronoun which. In the other three items measuring Relative 15 (Items 14, 40, 44) the relative clauses are signalled by the relative pronoun which following the preposition. As discussed earlier, these relative pronouns help a reader identify the presence of relative clauses and at the same time direct the reader's attention to the noun antecedents.

This interpretation of the effect of the relative pronouns that and which is consistent with Brown's (1971) research. He found that the relative pronouns that and which induced similar effects.

It is also of interest to examine if there were any differences to be discerned between centre-embedded relative sentences and right-branching relative sentences included in the present study. The data in Table 60 reveal that higher comprehension scores were obtained for the right-branching relative sentences (73.6% correct) when compared to the centre-embedded relative sentences (61.3%). The difference was statistically significant (see Table 61).

Table 60

Raw Scores and Percent Correct Responses on Right-branching
and Centre-embedded Relative Sentences

	Good Readers (N = 40)		Poor Readers (N = 43)	
	Right- branching	Centre- embedded	Right- branching	Centre- embedded
<u>Non-finite</u>				
<u>Relatives</u>				
Relative 11: Item 17		14		10
	32	35		18
	38	31	15	
Relative 12: Item 4		33		21
	8	12		8
	35	23	17	
<u>Finite</u>				
<u>Relatives</u>				
Relative 13: Item 2		35	25	
	36	23	16	
	41	22		16
Relative 12: Item 12		30		22
	19	26	20	
	30	35	18	
Relative 15: Item 14		33	22	
	40	29		15
	44	21		22
<u>TOTAL</u>		206	133	132
		(73.6%)	(44.2%)	(38.4%)

Table 61
Placement of Responses of English Relative Clauses in
Pass and Fail Categories

		Position of Relative Clauses		
		Right-branching	Centre-embedded	Total
Test Item	Pass	206	124	330
	Fail	74	196	270
	Total	280	320	600

$$\chi^2 = 73.16 \text{ (df = 1); } p < .001$$

Poor readers. No significant differences were obtained from comparisons of the comprehension scores of poor readers on each of the relatives. As seen in Table 59, the percentage of their correct responses ranged from 33.3 to 46.5 for Relatives 11, 12, 13, 15 & 14 respectively. These low percentage scores indicate that finite and non-finite relative sentences are all difficult for poor readers to comprehend. The types of mistakes made by poor readers were similar to the types of mistakes made by good readers. Poor readers however made more.

Good readers vs poor readers. Comparisons of good and poor readers' comprehension scores on all types of relative structures yielded statistically significant (see Table 62). These differences imply that relative structures are comprehensible for good readers but incomprehensible for poor readers. Common mistakes made by the subjects are discussed below.

(i) Item analysis of non-finite relative clauses preceded by participial -ed/-en (Relative 11) show that good and poor readers made similar types of mistakes. They either (i) in the case of a centre-embedded relative clause, wrongly identify a subject noun phrase of the main clause (as in Item 17), or (ii) in the case of a right-branching relative clauses, wrongly identify the subject noun phrase of an embedded

clause (as in Item 38). To illustrate, the subjects who failed Item 17, thought that either "these particular carbons are converted to an -OH group" or "any hydrogen is converted to an -OH group" were correct interpretations of the test sentence. For Item 38 where the relative clause is right-branching, the subjects regarded the following sequence of words as correct, "cellulose is composed of a rigid wall of a fungus". As pointed out earlier, relative pronouns and copulas are absent from the surface structure of this type of relative clause. Accordingly no clue is available to signal the existence of an embedded clause. Poor readers might be confused as to which noun phrase becomes a subject of a main clause and which is an appropriate subject noun phrase of an embedded clause.

(ii) For Relative 12, a common type of mistake made by good and poor readers seems to result from the inability to recognize a relative clause preceded by participial -ing. As seen in Item 8, good and poor readers who failed this item thought that what carries a current on its surface was either (i) the magnetic field inside a cylinder, or (ii) a magnetic field. Poor readers obviously made these mistakes more than did the good readers.

Table 62

Means, Standard Deviations and to-test Results for Good (N = 40)
and Poor Readers (N = 43) on the Five Relative Structures

	Good Readers		Poor Readers		t-Ratio	Probability
	Mean	SD	Mean	SD		
<u>Non-finite</u>						
<u>Relatives</u>						
Relative 11	2.00	0.68	1.00	0.66	6.83	.000
Relative 12	1.70	0.82	1.07	0.83	3.48	.001
<u>Finite</u>						
<u>Relatives</u>						
Relative 13	2.00	0.88	1.33	0.81	3.65	.000
Relative 14	2.28	0.88	1.40	0.88	4.57	.000
Relative 15	2.08	0.76	1.40	0.90	3.69	.000

(iii) While good readers obtained higher comprehension scores on finite relative clauses that were signalled by the relative pronouns that or which (as in Items 36 and 12), poor readers still found these structures difficult to comprehend. As shown in Table 59, good readers achieved 66.6 percent and 75.8 percent correct responses on Relatives 13 and 14; whereas poor readers achieved only 44.1 percent and 46.5 percent. Item analysis reveals that both good and poor readers who did not get the correct meaning of relative sentences where the relative pronouns that and which are present on the surface structure, tend to get confused as to which noun phrase becomes a subject of a main clause and which one is a subject of the embedded clause. The following mistakes were commonly found:

1. The subjects tended to consider a sequence of words at the end of a sentence as a kernel sentence, when a relative clause was centre-embedded. For example, they considered that "orbitals for bonding have sp^2 hybridization" was a kernel sentence of Item 41.

2. The subjects tended to be unable to identify the subject of the main clause where the relative clause was centre-embedded. For example, they thought the noun phrase "many substances" was the sentence subject, instead the noun cluster "many substances which normally are isotropic".

3. The subjects tended to treat the subject of the main clause as the subject of the embedded clause which was right-branching. For example, "multicellular organisms" was thought to be the subject of "exceedingly sensitive" in Item 36.

4. The subjects tended to consider a noun cluster as the subject of the embedded clause which was right-branching. For example, they considered that it was "the source of the ozone layer" which "envelops the earth".

(iv) An inspection of the mistakes made by good and poor readers on Relative 15 again showed that both groups made similar types of mistakes, a higher number being made by poor readers.

In the case of centre-embedded relative clause, for example, they tended to consider a sequence of words at the end of the sentence as a kernel sentence. As seen in Item 40, the subjects chose as the

kernel sentence the following sequence of words, "an isolated atom may be found in atomic orbitals".

For the right-branching relative clause, as in Item 14, the subjects seemed to take no notice of the embedded clause. They treated it instead as a prepositional noun phrase. For example, they thought that the correct interpretation of the sentence was "the electric field points in the direction of the electric potential".

Conclusions

This chapter has been devoted to an interpretation and discussion of: (i) the relationship between Thai science students' comprehension of English complex structures and their reading comprehension of scientific English passages, (ii) the patterns among comprehensibility levels of complex structures for good and poor readers and (iii) the differences in the comprehensibility of complex structures within given types for good and poor readers, taken separately.

It has been pointed out that for the subjects of the present study -- males and females, comprehension of English complex structures and reading comprehension of scientific English is positively related. When good and poor readers' patterns of the comprehensibility levels of complex structures are compared, there is a group of structures which is easy for both groups and that there is another group of structures which tends to be difficult for both groups in relation to the other structures. Easy structures seem to share a general feature -- the presence of particular types of surface cues in the surface structures. Another general feature seems to be that all surface elements are present and there is a tendency for the order of surface elements within clauses not to be changed. The difficult structures, on the other hand, share different types of surface cues or the surface cues are absent from the surface structure. Moreover, in these difficult structures, not all surface elements are present. The reader has to search for them elsewhere.

An inspection of the comprehensibility levels of complex structures within the different types seems to indicate that the presence of surface cues in the surface structure increases sentence comprehensibility. The absence of surface cues, on the other hand, tends to

increase sentence difficulty. The easier structures in the present study tended to contain the surface elements required to understand the sentence. Anaphoric references in such sentences, if there is any, can be found within a sentence boundary. There is no need then to look for reference outside the sentence boundary. The position of the relative clause seems also to have an effect on the comprehensibility level of relative sentences. Right-branching relative clauses seemed to be more comprehensible than centre-embedded relative clauses. Finally, the data of the present study seem to reveal that, in most of the easier structures, the order of surface elements has not been changed.

The next chapter will focus on conclusions, implications for educational practice and recommendations for future research.

CHAPTER 7

CONCLUSION AND EDUCATIONAL IMPLICATIONS

The purpose of the present chapter is three fold -- to provide an overall conclusion of the study, to identify some of the educational implications of the findings and comment on some implications for future research.

General Conclusion

This study had its origin in a concern for the problems that Thai students were thought to be having in the process of using foreign language textbooks in the study of science. At that point, it was believed that unfamiliarity with the foreign language would be coming between the students and their full understanding of science as it was being presented. It was also believed that in such a context, understanding of science was dependent on understanding of the English medium -- as it featured in the textbooks. Furthermore, it was thought that the language "errors" being made were probably systematic and probably occurred at both surface structure and deep structure levels.

Given that knowledge of science is important for Thai students, anything that could be done to identify impediments (and subsequently remove them) should be valuable. In approaching the task, a particular perspective was adopted -- a transformational grammar one. Grammatical analysis was used to provide an order base for approaching the problem and for identifying the types of difficulties students were experiencing.

It is not the first time such a problem has exercised linguists. For over a decade, linguists and language specialists have been attempting to provide English language teaching materials which would be appropriate for students whose first language was not English. Some linguists tried to arrive at solutions through the study of the language of science -- its lexical and syntactical characteristics. They believed that what was taught should reflect the kind of language students need to learn. Other linguists instead, emphasized the communicative aspects of science language (Widdowson, 1974, 1977) and the rhetorical functions of scientific discourse (Lackstrom, Selinker, & Trimble, 1973). Such attempts have all reflected great concern for students faced with learning

the English language. However effective learning and teaching of English for Science and Technology (EST) may be dependent on more than what has been considered appropriate by linguists. Reading in a foreign language is a complex process. It involves an interaction between the language and the reader. Accordingly factors which are related to the reader -- their reading problems, their interest, their reading ability should also be taken into account if successful teaching and learning is to occur.

The present study chose to place an emphasis on making use of the knowledge offered by linguists to study reading difficulties related to language structure. The ultimate goal was to examine ways in which Thai science students' reading comprehension might be improved.

The research questions posed in the study required that some attention be given to: (i) examining the relationship between reading comprehension of scientific English passages and comprehension of English complex structures, (ii) determining the relationship between the patterns of comprehensibility of the complex structures and reading ability, and (iii) measuring the comprehensibility levels of the complex structures encountered by science students in the reading of science textbooks.

For the investigation, a group of 190 science students was selected. The students' reading comprehension of scientific English passages was measured by a Cloze Reading Comprehension Test and their comprehension of English complex structures by a Test of English Grammatical Structures. Both tests were constructed by the author. The reading passages in both tests were all taken from science textbooks in current use. The subjects also had to translate into Thai the test sentences which appeared in the Test of English Grammatical Structures. Thereupon the research issues became: (i) how well could the students read their set texts and (ii) how much difficulty could be located in the complex structures they encountered.

A further interest of the study was to investigate comprehension of the complex structures. The purpose was to determine at what points good and poor readers were similar in their understanding the structures and at what points they were different. Justification has been provided

by Golinkoff (1975-76):

... contrasting good and poor comprehenders may have pedagogical implications. To design reading comprehension instruction for the beginning reader or for the reader requiring remediation, it may be useful to determine at what points in the process good and poor comprehenders do and do not diverge (p.626).

In the event, analyses and comparisons of the comprehension scores revealed that reading comprehension of scientific English passages and comprehension of the complex structures were positively related and that reading ability did not seem to affect the comprehensibility of the complex structures. There was a certain group of complex structures which was relatively easier for both groups and there was another group of complex structures which was relatively harder for both groups. There was none exclusively difficult or easy for any one group. Predictably not all of the structures of the same type were equally difficult or easy for the readers.

In the following section, attention will be given to some of the educational implications of the findings.

Educational Implications

Problems related to the research questions posed in the present study are commonly found in EST classroom situations. Accordingly the findings which answered these research questions can be considered to have some relevance for classroom EFL/EST teachers. Curriculum planners and language textbook writers may also find the results to be of interest.

Cloze technique

EST teachers occasionally need to evaluate their students' ability to understand scientific English passages. A language test which determines this specific reading proficiency of scientific English is not available. A common practice therefore is to use other language tests. Such tests however generally contain reading passages of general English. As a result, conclusions about reading comprehension of scientific English are taken as it were, one step removed from scientific

reality. The cloze technique, previously used to measure foreign students' reading comprehension of general English has, in the present study, been taken one step further by applying it to "science" English and establishing, in the process, its reliability and validity. Accordingly, EST classroom teachers might utilize the technique to construct their own tests. For teaching purposes, language teachers could construct their own reading tests based on scientific English passages -- using the cloze technique and their knowledge of science. Such tests are easy to construct and yield results similar to those obtainable from multiple-choice reading tests.

Cloze scoring methods

Two cloze scoring methods -- the exact-word and the acceptable-word scoring methods -- were also examined in the present study. Some previous cloze research had shown the acceptable-word scoring method to be "superior in terms of item discrimination and validating correlations regardless of the level-of-difficulty of the test" (Oller, 1972, p. 157). Again another researcher had found that both scoring methods were reliable and efficient (Anderson, 1972). As the exact-word scoring method is simple and easy to apply, less time-consuming, and requires no judgement as to which answer is acceptable, language teachers who were not native English speakers had tended to prefer this method.

The data from the present study tended to support Anderson's findings which had shown that there was no significant difference between the two methods. Language teachers would appear to be on safe ground when using the exact-word scoring method. However caution is necessary in using either of the methods. Adopting only the exact-word scoring method when the purpose, for example, is for remedial instruction, may not yield a fruitful result. When the cloze test is constructed to examine each individual student's reading difficulty, an acceptable-word scoring method may be more appropriate.

Scientific English and its relationship to language structure

The moderately high correlation found between comprehension of scientific English and comprehension of the complex structures tends to provide some reassurance that instruction aiming to help science students improve their reading of scientific English by making use of syntactic clues to derive meaning, is worthwhile.

However some doubt remains whether one should emphasize the teaching of sentence grammar in reading classes (Davies, 1979). Some research dealing with science students had found that students could understand sentences but could not grasp the meaning of connected discourse. These researchers concluded that teaching reading by the rhetorical approach might overcome the problem. Such an approach focuses on paragraph rather than sentence level as the basic unit of discourse. The argument was that reading comprehension might be improved if knowledge of the rhetorical functions of the paragraph and the rhetorical elements which unite sentences and paragraphs were acquired. The present study provides no grounds for arguing against the rhetorical approach or promoting a syntactical one. However there does appear to be some logic in arguing that reading instruction which emphasizes an awareness of sentence syntactic clues should be encouraged when the students do not yet have control of sentence grammar. Science students with reading difficulties might well be encouraged to learn to make use of syntactic clues to complement other reading skills. Full understanding of the connected discourse depends to some extent on understanding the meaning of sentences. Such a statement does not necessarily imply that in order to have a full understanding of longer scientific English discourse, a reader has to understand every sentence. As Goodman (1976) stated, reading is a psycholinguistic guessing game. A proficient reader reads selectively. He looks for the key sentences and tries to get the meaning. Having good control of the sentence structure would be of benefit for a reader to derive a correct interpretation of the sentence.

In general English passages, the whole is probably greater or rather different from the sum of the parts. In scientific English this may be the case, it may also not be. Given the logic of science and its precision sometimes, each separate part may have to be fully comprehended if the whole is to be understood at all.

Patterns of complex structures comprehension and reading ability

The fact that there was a high and significant correlation between the patterns of comprehensibility levels of the complex structures for good and poor readers indicated that, of the complex structures encountered, most were relatively easier and harder alike for both groups. These findings are relevant for curriculum planners, textbook

writers and language teachers, for they provide a basis for sequencing various types of complex structures. As shown in Chapter 5, the data revealed that those structures which were easier in relation to other structures for both groups, did not belong to any one particular type. They included (i) Comparison of inequality with the presence of than, (ii) Comparison of similarity with the comparative element same, (iii) Finite (which - subject) relative, (iv) Finite(which-complement to preposition) relative. Accordingly, it would seem unnecessary to delay the introduction of all complex structures on the assumption that all complex structures would be difficult. Some easier structures could be introduced earlier and in this way possibly aid the understanding of harder ones when they were presented later. For language teachers, the information on general features shared by a group of easier structures might help in guiding students to cope with complex structures.

Comprehensibility levels of the complements, the comparatives and the relatives for good and poor readers taken separately

The fact that there were significant differences among the various structures within the same type might be relevant for both language textbook writers and language teachers who have to cope with remedial instruction.

For language textbook writers, information such as "to-infinitive" complement structures are more difficult than finite complements might, for example, serve a good basis for determining the order in which tasks might be introduced.

The identification of problems in understanding (for example, complement structures) might also be useful for reading teachers in (i) promoting awareness of reading difficulties, (ii) providing means for helping students to make use of syntactic clues to get sentence meaning.

The Test of English Grammatical Structures

The test was developed on the assumption that the 15 complex structures included were commonly encountered by science students and that they might hinder sentence understanding. The test be used with first year Thai science students was considered as a satisfactory and

reliable measure. This implies that the test could be used with confidence on other groups of Thai science students.

Perhaps as a footnote to the more specific points made about it would be appropriate to make a final general one. By and large the science texts in use were not easy to comprehend - possibly even for native English speakers. The grammatical complexity and language sophistication they characteristically displayed may well be not only incidental to the process of promoting understanding of science but even antithetical too. There seems to be a need for simply expressed scientific texts that help rather than hinder the readers' science education.

Implications for Future Research

1. The present study covered only science students from one university in Thailand -- Khon Kaen University. Accordingly, generalizations on (i) the relationship between reading comprehension of scientific English and comprehension of the complex structures and (ii) the comprehensibility levels of the complex structures, cannot be drawn. Selective replication would be necessary to provide a satisfactory basis for doing so.

2. The linguistic areas selected for the present study are not exhaustive. Several other areas which science students face in reading texts and which tend to be problematic ones; such as "complex noun phrases", "anaphoric references", "adjunction" etc., also merit investigation.

3. Investigation of the reading comprehension of science students in the present study was limited only to some scientific English passages and English complex sentences drawn from basic science texts of three areas of science -- Biology, Chemistry and Physics. Other specialized fields e.g. medicine, engineering and agriculture also warrant investigation.

4. There is scope for further research into a number of grammatical features. The results of the present study suggest at least the following:

- (i) effects of clause-order on variations of the finite complements,

- (ii) effects of the position of relative clauses, and the role of the grammatical functions of the coreferential noun phrases, on the comprehensibility of subject relative sentences for non-native English speakers.

Finally before any of the results are applied in either language teaching or in the writing of scientific texts, there is a case for testing empirically whether inferred "improvements" would in fact work -- and that comprehension is in fact, improved.

However, such a conclusion though scientifically proper may in fact be pragmatically improper. Currently, Thai students are facing difficulties in comprehending science texts. They should not be expected to continue to struggle until a perfect solution has been developed or proven.

APPENDIX A

Cloze Reading Comprehension Test

ตัวอย่าง

(Example)

คำสั่ง :

(Instructions)

อ่านตัวอย่างต่อไปนี้แล้วหาคำที่เหมาะสมเติมลงในช่องว่าง
 ของว่างแต่ละช่องของการคำเพียง คำเดียว จงเขียน
 คำตอบลงในกระดาษคำตอบ

(Read the following examples. Fill in the blanks with the appropriate words. Fill in only one word for each blank. Write your answers on the answer sheet provided.)

Our school

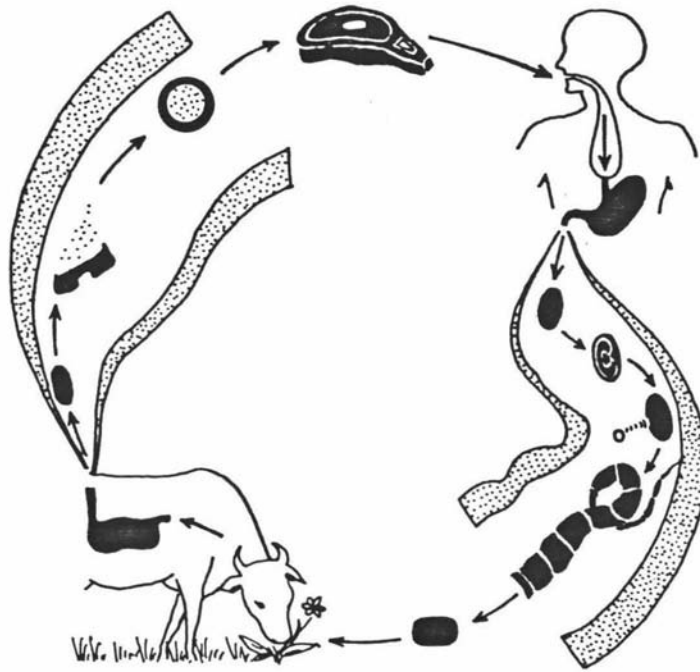
Boys (1) girls go to our school. At (2) we learn to read. We also learn how (3) write.

The Count-down

"Ten, Nine, Eight, (4), Six, Five, Four, Three, (5), One, Fire!" Up goes the rocket. Way up into (6) sky. Faster and faster (7) goes, till no one can (8) it.

กรุณาอย่าพลิกหน้าทอไปจนกว่าจะไ้รับคำสั่ง
 จากอาจารย์คุมสอบ

(Do not turn over the page until you are told to do so.)



6.20 Beef tapeworm life cycle

Ripe sections of the worm pass with the feces from the human gut. Eggs are released from these sections in the gut of cattle. Walled, hook-bearing tapeworm embryos then encapsulate in beef muscle, and the embryos become adults in the intestine of man. The head (scolex) of the worm is invaginated at first, but it soon everts, and with the hooks and newly developed suckers it attaches to intestinal tissues.

PARASITIC REPRODUCTION

Parasites typically are exceedingly prolific. The enormous reproductive potential represents a solution of a major problem confronting the parasite, particularly the endoparasite: how to get from one host to another of the same species. Parasites succeed by active transfer and passive transfer, both of which involve reproduction. In active transfer, one stage of the life cycle is free-living and motile, and this stage transfers from one host to another through its own powers of locomotion. For example, the adult may be parasitic but the embryo or larva is free-living and capable of locomotion. Or the immature phase may be the parasite, the adult then being free-living and motile.

Passive transfer is encountered where a (1) is not motile at any life-cycle (2). Propagation here is accomplished by wind, (3) water, or by intermediate hosts. The (4) offer a means of transfer not (5) as chancy as distribution by wind (6) water. For example, tapeworms use one (7) the easiest routes into and out (8) their human hosts, the alimentary tract. (9) through the host's mouth by way (10) eaten food, tapeworms spend their life (11) in the gut cavity of man, (12) they release their eggs through the (13) of the host, along with feces. (14) problem now is to transfer by (15) means to another human host.

Since (16) does not eat feces, the eggs (17) not reach new human hosts directly. (18) tapeworms take advantage of the food (19) of which man is a member; (20) eats beef, and cattle eat grass. (21) ready-made pathway from grass to man (22) exists, and transfer can be achieved (23), as happens on occasion, human feces (24) deposited on grass. Tapeworm eggs clinging (25) such vegetation then are often eaten (26) cattle (Fig.6.20).

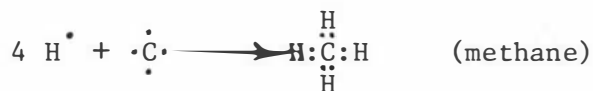
In the intestine (27) a cow, a tapeworm egg develops (28) an embryo that bores a path (29) the gut wall into the cow's (30) stream. From there the embryo is carried to beef muscle, where it encapsulates and matures. If man later eats raw or partially cooked beef, the capsule surrounding the young tapeworm is digested in the human gut and the free worm hooks on to the intestinal wall of its new host.

CHEMICAL BONDS AND MOLECULAR STRUCTURECOVALENT BONDS

While the complete transfer of an electron from one atom to another is a suitable way for a sodium and a chlorine atom to achieve the rare gas configuration, it is not energetically favorable when the two atoms involved do not differ greatly in electronegativity. Neither is it suitable when one of the atoms concerned is an element near the center of the periodic table, because in that event the transfer of the number of electrons required to give the rare gas configuration will result in too great a concentration of positive or negative charge on the atom. Thus were carbon to acquire a rare gas configuration in this manner, it would have to gain or lose four valence electrons, giving either C^{4-} or C^{4+} .

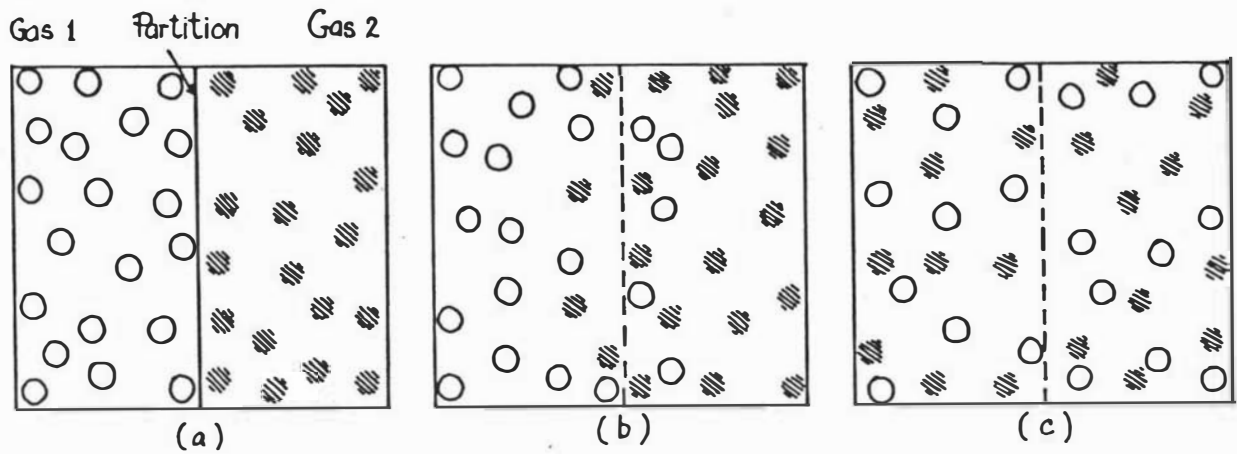
In these cases atoms resort to (1) process of electron sharing in order (2) achieve filled outer shells; that is (3) pair of outer-shell valence electrons are (4) between a pair of atoms. As (5) simplest possible example let us consider (6) gas, H_2 , in which the two (7) atoms each share their combined valence (8).

$H \cdot + H \cdot \longrightarrow H:H$ (a dot represents (9) electron)
Such a sharing of a (10) of valence electrons represents a covalent bond. (11) the fact that they are shared (12) the two hydrogens, the two electrons (13) to fill the outer shell of (14) atoms. In other words, for the (15) of acquiring a rare gas configuration (16) its outer electronic shell, an atom (17) be considered to "own" all the (18) it shares in covalent bonds with (19) atoms. Usually the number of covalent (20) an atom forms will be equal (21) the additional number of electrons needed (22) achieve a rare gas configuration for (23) outermost electron shell. Thus carbon normally (24) four, nitrogen three, and oxygen two (25) bonds. Methane, CH_4 , illustrates the formation (26) four covalent bonds by carbon through (27) sharing of four electron pairs with (28) atoms.



(only (29) shell electrons shown)

As a result (30) this electron-sharing process the carbon atom of methane has in effect filled its outer electronic shell.



14.1 Gaseous diffusion. (a) The two gases are held separate by the partition. (b) Shortly after the partition is removed, a few molecules of each gas are found on the other's side. (c) After a certain time the mixture of the two gases is homogeneous, and no further diffusion takes place.

TRANSPORT PHENOMENAINTRODUCTION

The fact that molecules in gases and liquids (and to a lesser extent in solids) are in continuous motion gives rise to a series of important physical processes of statistical nature which have certain common features and which are known under the general heading of transport phenomena. Transport phenomena are those processes in which there is a net transfer (or transport) of either matter, energy, or momentum, in a bulk of macroscopic amount. In this chapter we shall briefly discuss three kinds of transport phenomena: (a) molecular diffusion, (b) thermal conduction, and (c) viscosity.

MOLECULAR DIFFUSION: FICK'S LAW

We know that when we open (1) bottle of perfume or of any (2) liquid having a distinct odor, such (3) ammonia, we can smell it very (4) in remote parts of a closed (5). We say that the molecules of (6) liquid, after evaporating, diffuse through the (7), spreading into all the surrounding space. (8) same thing happens if we place (9) sugar cube in a glass of (10). The sugar dissolves gradually, but at (11) same time the dissolved sugar molecules (12) through the water, and eventually are (13) throughout the water. As a final (14), if there are two gases in (15) partitioned vessel, as shown in Fig. 14.1, (16) we remove the partition, the two (17) diffuse into each other until, after (18) short time, we have a homogeneous (19). These and many other examples familiar (20) the student illustrate a fundamental characteristic (21) the diffusion process:

Diffusion occurs whenever (22) space distribution of the molecules of (23) substance varies from place to place.

(24) us call n the number of (25) of the diffusing substance per unit (26) (this will be called the concentration (27) the substance). According to the above (28), this number must vary from place (29) place in order for diffusion to (30).

A second characteristic is that

Diffusion (molecular transport) occurs in the direction in which the concentration decreases,

and therefore tends to equalize the molecular distribution of the diffusing substance over all space.

กระดาษคำตอบ
(Answer Sheet)

หมายเลขข้อสอบ
(Test Number)

ชื่อ
(Name)
คณะ
(Faculty)

(Example)

- | | | |
|----------|----------|----------|
| 1. _____ | 4. _____ | 7. _____ |
| 2. _____ | 5. _____ | 8. _____ |
| 3. _____ | 6. _____ | 9. _____ |

PARASITIC REPRODUCTION

COVALENT BONDS

TRANSPORT PHENOMENA

- | | | |
|-----------|-----------|-----------|
| 1. _____ | 1. _____ | 1. _____ |
| 2. _____ | 2. _____ | 2. _____ |
| 3. _____ | 3. _____ | 3. _____ |
| 4. _____ | 4. _____ | 4. _____ |
| 5. _____ | 5. _____ | 5. _____ |
| 6. _____ | 6. _____ | 6. _____ |
| 7. _____ | 7. _____ | 7. _____ |
| 8. _____ | 8. _____ | 8. _____ |
| 9. _____ | 9. _____ | 9. _____ |
| 10. _____ | 10. _____ | 10. _____ |
| 11. _____ | 11. _____ | 11. _____ |
| 12. _____ | 12. _____ | 12. _____ |
| 13. _____ | 13. _____ | 13. _____ |
| 14. _____ | 14. _____ | 14. _____ |
| 15. _____ | 15. _____ | 15. _____ |
| 16. _____ | 16. _____ | 16. _____ |
| 17. _____ | 17. _____ | 17. _____ |
| 18. _____ | 18. _____ | 18. _____ |
| 19. _____ | 19. _____ | 19. _____ |
| 20. _____ | 20. _____ | 20. _____ |
| 21. _____ | 21. _____ | 21. _____ |
| 22. _____ | 22. _____ | 22. _____ |
| 23. _____ | 23. _____ | 23. _____ |
| 24. _____ | 24. _____ | 24. _____ |
| 25. _____ | 25. _____ | 25. _____ |
| 26. _____ | 26. _____ | 26. _____ |
| 27. _____ | 27. _____ | 27. _____ |
| 28. _____ | 28. _____ | 28. _____ |
| 29. _____ | 29. _____ | 29. _____ |
| 30. _____ | 30. _____ | 30. _____ |

APPENDIX B

Multiple-choice Reading Comprehension Test

คำแนะนำ
(Instructions)

ข้อสอบวัดความรู้ความเข้าใจการอ่านเนื้อเรื่องที่คัดลอกมาจากตำราวิทยาศาสตร์ ซึ่งมีทั้งหมด 3 เรื่อง ในแต่ละเรื่องท่านจะได้รับการทดสอบทั้งความเข้าใจคำศัพท์ (Part A) และความเข้าใจเนื้อเรื่องที่อ่าน (Part B) โดยมีคำถามเรื่องละ 20 คำถาม

ท่านจะพบว่าคำศัพท์ใน Part A คัดเลือกมาจากเรื่องแต่ละเรื่องที่ท่านอ่าน ดังนั้นจึงเห็นได้จากหมายเลขที่กำกับอยู่ คำศัพท์แต่ละคำมีความหมายไว้ให้เลือก 4 ความหมาย คือ a, b, c, d ท่านจงอ่านประโยคที่มีคำศัพท์นั้น ๆ ปรากฏอยู่ให้เข้าใจให้ละเอียดเสียก่อน แล้วจึงตัดสินใจว่า a หรือ b หรือ c หรือ d เป็นความหมายเดียวที่เหมาะสมกับใจความตอนนั้นมากที่สุด.

(This test is to measure reading comprehension of three passages drawn from science textbooks. For each passage, your knowledge of vocabulary (Part A) and understanding of the passage (Part B) will be tested. There are 20 questions for each passage.

The words in Part A were taken from the preceding passage. These words were marked by numbers. Four alternative meanings will be given for each word. To decide whether the meaning of a or b or c or d is the most appropriate one for each word tested, read the sentence where the word appears to get the correct meaning.)

ตัวอย่าง :

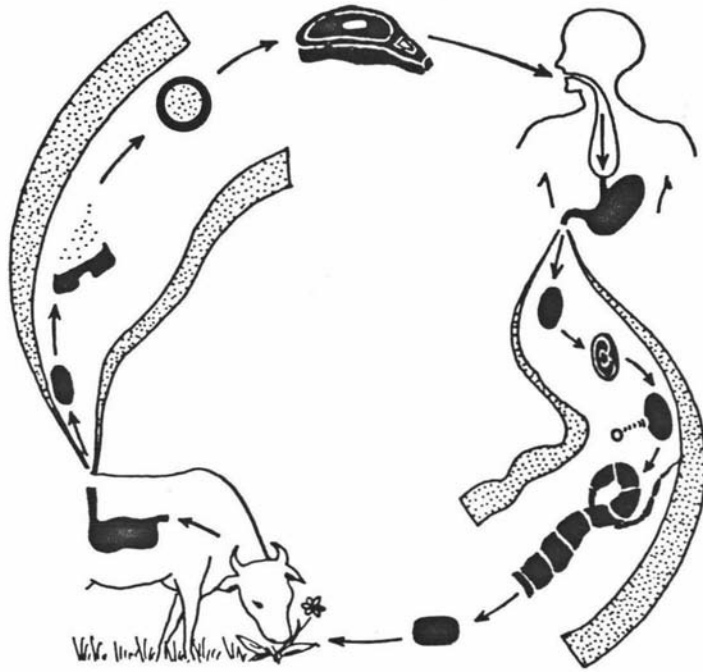
(Example)

The fact that molecules in gases and liquids are in continuous motion gives rise to a series of important physical processes of statistical nature which have certain common features

1. common (a) well known
(b) general
(c) belonging to all
(d) shared

ความหมายของคำ common ที่เหมาะสมที่สุดสำหรับประโยคข้างต้น คือ (d)

((d) is the most appropriate meaning for the word common.)



6.20 Beef tapeworm life cycle

Ripe sections of the worm pass with the feces from the human gut. Eggs are released from these sections in the gut of cattle. Walled, hook-bearing tapeworm embryos then encapsulate in beef muscle, and the embryos become adults in the intestine of man. The head (scolex) of the worm is invaginated at first, but it soon everts, and with the hooks and newly developed suckers it attaches to intestinal tissues.

PASSAGE I

Parasites typically are exceedingly prolific. The enormous reproductive potential represents a solution of a major problem confronting the parasite, particularly the endoparasite: how to get from one host to another of the same species. Parasites succeed by "active transfer" and "passive transfer", both of which involve reproduction. In active transfer, one stage of the life cycle is free-living and motile, and this stage transfers from one host to another through its own powers of locomotion. For example, the adult may be parasitic but the embryo or larva is free-living and capable of locomotion. Or the immature phase may be the parasite, the adult then being free-living and motile.

Passive transfer is encountered where a parasite is not motile at any life-cycle stage. Propagation here is accomplished by wind, by water, or by "intermediate hosts". The last offer a means of transfer not quite as chancy as distribution by wind or water. For example, tapeworms use one of the easiest routes into and out of their human hosts, the alimentary tract. Entering through the host's mouth by way of eaten food, tapeworms spend their life directly in the gut cavity of man, and they release their eggs through the anus of the host, along with feces. The problem now is to transfer by passive means to another human host.

Since man does not eat feces, the eggs cannot reach new human hosts directly. However, tapeworms take advantage of the food pyramids of which man is a member; man eats beef, and cattle eat grass. A ready-made pathway from grass to man thus exists, and transfer can be achieved if, as happens on occasion, human feces are deposited on grass. Tapeworm eggs clinging to such vegetation then are often eaten by cattle (Fig. 6.20).

In the intestine of a cow, a tapeworm egg develops into an embryo that bores a path through the gut wall into the cow's blood stream. From there the embryo is carried to beef muscle, where it encapsulates and matures. If man later eats raw or partially cooked beef, the capsule surrounding the young tapeworm is digested in the human gut and the free worm hooks on to the intestinal wall of its new host.

(366 words)

Part A:

จงเลือกความหมาย เดียว ที่ท่านคิดว่าเหมาะสมที่สุดที่จะเป็นความหมายของคำศัพท์แต่ละคำที่ปรากฏอยู่ในใจความที่ท่านได้อ่านมาแล้วข้างต้น (โปรดสังเกตหมายเลขที่กำกับอยู่)

ทำเครื่องหมาย (X) ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ.

(Choose the best meaning for the following words. These words were taken from the passage you have just read.

Refer to the numbers preceding the words in the passage.

Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

- | | | | |
|-----------------------|------------------|------------------------|-----------------------|
| 1. <u>exceedingly</u> | (a) extremely | 5. <u>propagation</u> | (a) advantage |
| | (b) usually | | (b) growth |
| | (c) occasionally | | (c) spreading |
| | (d) possibly | | (d) solution |
| 2. <u>prolific</u> | (a) numerous | 6. <u>accomplished</u> | (a) presented |
| | (b) rare | | (b) done |
| | (c) dangerous | | (c) followed |
| | (d) small | | (d) destroyed |
| 3. <u>motile</u> | (a) active | 7. <u>encapsulates</u> | (a) breaks a capsule |
| | (b) strong | | (b) leaves a capsule |
| | (c) sensitive | | (c) digests a capsule |
| | (d) moving | | (d) builds a capsule |
| 4. <u>encountered</u> | (a) produced | 8. <u>matures</u> | (a) increases |
| | (b) completed | | (b) develops |
| | (c) found | | (c) produces |
| | (d) stopped | | (d) lives |

Part B:

จงเลือกคำตอบที่ตอบคำถามต่อไปนี้ได้ใกล้เคียงที่สุด แล้วทำเครื่องหมาย (X) ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ

(Choose the most appropriate answer for the following questions. Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

9. What is the major problem facing parasites?
- How to take advantage of the food pyramids
 - How to spend their lives safely in the gut cavity of man
 - How to transfer from one human host to another human host
 - How to reproduce enormous numbers of parasites

10. How many intermediate hosts are there in the life-cycle of a beef tapeworm?
- (a) none (c) two
(b) one (d) three
11. Where does a beef tapeworm egg develop into an embryo?
- (a) In the beef muscle
(b) In the liver of man
(c) In the intestine of a cow
(d) In the cow's blood stream
12. Where does a young beef tapeworm finally live?
- (a) In the gut cavity of man
(b) In the intestine of a cow
(c) In the beef muscle
(d) In the liver of man
13. Why is a transfer of a beef tapeworm egg from man to cow considered a "passive transfer"?
- (a) Because both man and cow are passive living creatures.
(b) Because a beef tapeworm egg is released and left on grass.
(c) Because a beef tapeworm egg is capable of locomotion.
(d) Because a beef tapeworm egg reaches its new host.
without making any effort
14. Why can't a tapeworm egg transfer directly from one human host to another new human host?
- (a) Because it is released with human feces.
(b) Because it is free-living and motile.
(c) Because it is often eaten by cattle.
(d) Because it is born in the gut cavity of man.
15. Why may a beef tapeworm appear in a human gut?
- (a) Because a beef tapeworm egg develops in the human gut.
(b) Because the beef tapeworm is free-living and motile at one stage of its life cycle.
(c) Because man's blood stream carries the tapeworm embryo into the human gut.
(d) Because man eats raw or partially cooked beef.
16. What is considered an intermediate host in the life-cycle of a beef tapeworm?
- (a) cow (c) feces
(b) man (d) grass
17. At what stage of the life-cycle of a beef tapeworm does it involve a "passive transfer"?
- (a) At the adult stage of the life-cycle
(b) At all stages of its life-cycle
(c) At the immature stage of its life-cycle
(d) At no stage of its life-cycle

18. What was first mentioned in the passage?
- (a) The life cycle of a beef tapeworm
 - (b) The problem facing parasites
 - (c) The types of transfer involved in parasitic reproduction
 - (d) The definition of an active transfer
19. What was finally discussed in the passage?
- (a) The definition of an active transfer
 - (b) The various means of passive transfer
 - (c) The advantage of the food pyramids
 - (d) The growth of a beef tapeworm
20. What is the main idea of the passage?
- (a) The reproduction of a beef tapeworm
 - (b) The descriptive explanation of "active transfer" and "passive transfer"
 - (c) The enormous reproductive potential of parasites
 - (d) The role of the food pyramids in parasitic reproduction

Part A:

จงเลือกความหมายเดียวที่ท่านคิดว่าเหมาะสมที่สุดที่จะเป็นความหมายของคำศัพท์แต่ละคำที่ปรากฏอยู่ในใจความที่ท่านได้อ่านมาแล้วข้างต้น (โปรดสังเกตุหมายเลขที่กำกับอยู่)

ทำเครื่องหมาย (X) ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ.

(Choose the best meaning for the following words. These words were taken from the passage you have just read.

Refer to the numbers preceding the words in the passage.

Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

- | | | | |
|-----------------------|--|----------------------------------|--|
| 21. <u>to achieve</u> | (a) to keep
(b) to earn
(c) to charge
(d) to make | 25. <u>resort to</u> | (a) start
(b) share
(c) help
(d) use |
| 22. <u>involved</u> | (a) concerned
(b) provided
(c) needed
(d) added | 26. <u>Despite the fact that</u> | (a) Because
(b) In addition to
(c) Although
(d) Instead of |
| 23. <u>to acquire</u> | (a) to get
(b) to attend
(c) to add
(d) to give | 27. <u>illustrates</u> | (a) causes
(b) shows
(c) results
(d) makes |
| 24. <u>manner</u> | (a) custom
(b) appearance
(c) way
(d) behavior | 28. <u>formation</u> | (a) preparation
(b) connection
(c) condition
(d) production |

Part B:

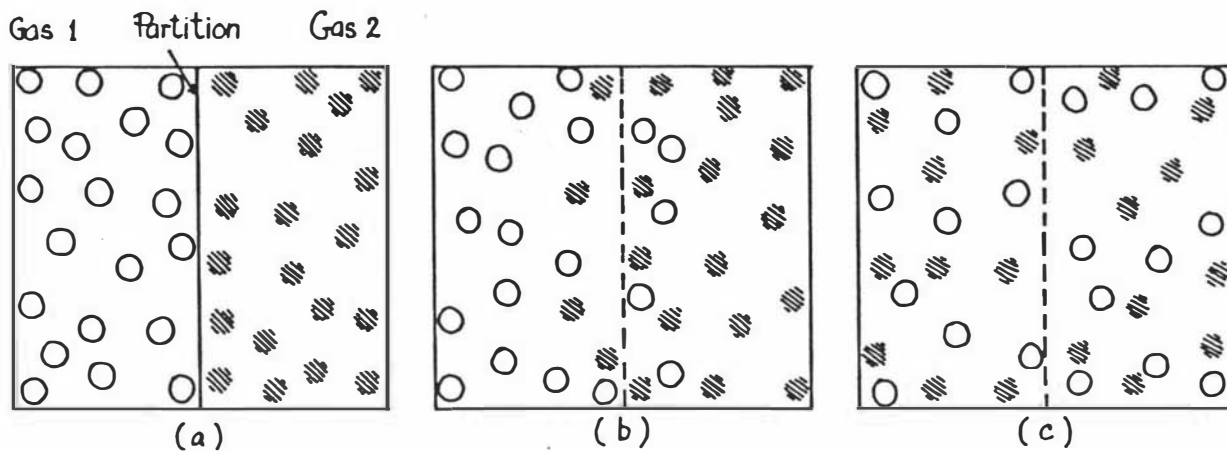
จงเลือกคำตอบที่รอบคอบตามข้อไปมีได้ใกล้เคียงที่สุด แล้วทำเครื่องหมาย (X) ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ

(Choose the most appropriate answer for the following questions. Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

29. In what condition do atoms achieve their rare gas configuration by a complete transfer of an electron from one atom to another?
- (a) When two atoms involved differ greatly in electronegativity.
 (b) When two atoms involved do not differ greatly in electronegativity.
 (c) When one of the atoms concerned is an element near the center of the periodic table.
 (d) Both a and c

30. How do atoms achieve filled outer shells if the two atoms involved do not differ greatly in electronegativity?
- (a) By a process of acquiring a rare gas configuration
 - (b) By a process of transferring completely an electron from one atom to another
 - (c) By a process of forming a concentration of positive or negative charge on the atom
 - (d) By a process of sharing electrons with one another
31. What does the example of hydrogen gas illustrate?
- (a) The complete transfer of an electron from one atom to another
 - (b) The two hydrogen atoms
 - (c) The sharing of a pair of covalent bonds
 - (d) The sharing of a pair of outer-shell valence electrons between a pair of atoms
32. What happens to the two electrons when two hydrogen atoms are involved in a rare gas configuration?
- (a) They form two pairs of covalent bonds.
 - (b) They act to fill the outer shell of one of the two atoms.
 - (c) They are shared by the two hydrogens.
 - (d) They add the number of electrons to one of the two atoms.
33. Why does the transfer of the number of electrons required to give the rare gas configuration result in too great a concentration of positive or negative charge on the atom?
- (a) Because one of the atoms concerned is an element near the center of the periodic table.
 - (b) Because the two atoms involved differ greatly in electronegativity.
 - (c) Because the two atoms involved do not differ greatly in electronegativity.
 - (d) Because one of the atoms concerned acquired a rare gas configuration.
34. Why is carbon referred to in the first paragraph?
- (a) To illustrate that a complete transfer of an electron from one atom to another is not a suitable way for carbon to acquire a rare gas configuration
 - (b) To illustrate that the electronegativity of carbon is great
 - (c) To illustrate that carbon forms four covalent bonds through the sharing of four electron pairs with other atoms
 - (d) To illustrate that a process of electron sharing is not favorable for carbon to achieve filled outer shells
35. Why is methane mentioned in the passage?
- (a) To illustrate that a pair of outer-shell valence electrons are shared between a pair of atoms
 - (b) To illustrate that the number of covalent bonds an atom forms is equal to the additional number of electrons needed to achieve a rare gas configuration
 - (c) To illustrate that the carbon atom of methane "owns" a number of outer shell electrons
 - (d) To illustrate that the carbon atom and the hydrogen atom differ greatly in electronegativity

36. What may be the reason for choosing a hydrogen gas as an example to explain the concept of covalent bond?
- (a) Its popularity
 - (b) Its simplicity
 - (c) Its electron-sharing process
 - (d) Its outer electron shell
37. Which is a suitable way for the carbon atom to acquire a rare gas configuration?
- (a) By a complete transfer of an electron from one atom to another
 - (b) By sharing the outer shell valence electrons with other atoms
 - (c) By gaining or losing four outer-shell valence electrons
 - (d) By achieving filled outer shells
38. What was first introduced in the passage?
- (a) An illustration of how carbon acquires its rare gas configuration
 - (b) The definition of a "covalent bond"
 - (c) A reason why a complete transfer of an electron from one atom to another is not suitable in some conditions
 - (d) An illustration of how the carbon atom of methane fills its outer electron shell
39. Which was last mentioned in the passage?
- (a) Ways to acquire a rare gas configuration
 - (b) An example of the carbon atom acquiring a rare gas configuration through the electron-sharing process
 - (c) An example of the carbon atom acquiring a rare gas configuration by a complete transfer of electrons
 - (d) A simple illustration of the concept of a "covalent bond"
40. Which is the main idea of the passage?
- (a) The advantage of an electron-sharing process
 - (b) The rare gas configuration of a carbon atom in methane
 - (c) The concept of a covalent bond
 - (d) The role of an outer-shell valence electron



14.1 Gaseous diffusion. (a) The two gases are held separate by the partition. (b) Shortly after the partition is removed, a few molecules of each gas are found on the other's side. (c) After a certain time the mixture of the two gases is homogeneous, and no further diffusion takes place.

PASSAGE III

INTRODUCTION

The fact that molecules in gases and liquids (and to a lesser extent in solids) are in continuous motion gives rise to a series of important physical processes of statistical nature which have certain common features and which are known under the general heading of transport phenomena. Transport phenomena are those processes in which there is a net transfer (or transport) of either matter, energy, or momentum, in a bulk of macroscopic amount. In this chapter we shall briefly discuss three kinds of transport phenomena: (a) molecular diffusion, (b) thermal conduction, and (c) viscosity.

MOLECULAR DIFFUSION: FICK'S LAW

We know that when we open a bottle of perfume or of any other liquid having a ⁽⁴¹⁾distinct odor, such as ammonia, we can smell it very quickly in ⁽⁴²⁾remote parts of a closed room. We say that the molecules of the liquid, after evaporating, ⁽⁴³⁾diffuse through the air, spreading into all the surrounding space. The same thing happens if we place a sugar cube in a glass of water. The sugar dissolves gradually, but at the same time the dissolved sugar molecules diffuse through the water, and ⁽⁴⁴⁾eventually are distributed throughout the water. As a final ⁽⁴⁵⁾illustration, if there are two gases in a partitioned vessel, as shown in Fig. 14.1, and we remove the ⁽⁴⁶⁾partition, the two gases diffuse into each other until, after a short time, we have a ⁽⁴⁷⁾homogeneous mixture. These and many other examples familiar to the student illustrate a ⁽⁴⁸⁾fundamental characteristic of the diffusion process:

Diffusion occurs whenever the space distribution of the molecules of the substance varies from place to place.

Let us call n the number of molecules of the diffusing substance per unit volume (this will be called the "concentration" of the substance). According to the above statement, this number must vary from place to place in order for diffusion to occur. A second characteristic is that

diffusion (molecular transport) occurs in the direction in which the "concentration" decreases,

and therefore tends to equalize the molecular distribution of the diffusing substance over all space.

Part A:

จงเลือกความหมาย เดียว ที่ท่านคิดว่าเหมาะสมที่สุดที่จะเป็นความหมายของคำศัพท์แต่ละคำ
ที่ปรากฏอยู่ในใจความที่ท่านได้อ่านมาแล้วข้างต้น (โปรดสังเกตุหมายเลขที่กำกับอยู่)

ทำเครื่องหมาย (X) ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ.

(Choose the best meaning for the following words. These words were taken from the passage you have just read. Refer to the numbers preceding the words in the passage.

Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

- | | | | |
|-----------------------|---|-------------------------|---|
| 41. <u>distinct</u> | (a) strange
(b) unpleasant
(c) familiar
(d) noticeable | 45. <u>illustration</u> | (a) possibility
(b) experiment
(c) example
(d) statement |
| 42. <u>remote</u> | (a) far
(b) small
(c) large
(d) near | 46. <u>partition</u> | (a) sapce
(b) remaining substance
(c) vessel
(d) dividing wall |
| 43. <u>diffuse</u> | (a) occur
(b) spread
(c) expand
(d) reduce | 47. <u>homogeneous</u> | (a) separate
(b) not complete
(c) evenly mixed
(d) dangerous |
| 44. <u>eventually</u> | (a) certainly
(b) usually
(c) possibly
(d) finally | 48. <u>fundamental</u> | (a) easy
(b) well known
(c) common
(d) important |

Part B:

จงเลือกคำตอบที่ตอบคำถามต่อไปนี้ได้ใกล้เคียงที่สุด แล้วทำเครื่องหมาย (X)
ลงบนอักษร a, b, c, หรือ d บนกระดาษคำตอบ

(Choose the most appropriate answer for the following questions. Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

49. When we open a bottle of perfume, how can we smell it in remote parts of a closed room?
- | | |
|-------------------|------------------|
| (a) very strongly | (c) very clearly |
| (b) very rapidly | (d) very easily |

50. The dissolved sugar molecules diffuse through the water ...
- (a) After the sugar cube dissolves.
 - (b) While the sugar cube dissolves.
 - (c) Because they are distributed throughout the water.
 - (d) After they have been distributed.
51. What was the third thing used to show molecular diffusion?
- (a) perfume
 - (b) sugar
 - (c) two gases
 - (d) ammonia
52. What happens after we remove the partition?
- (a) The concentration of one of the gases decreases.
 - (b) The molecules of the two gases are distributed throughout the container.
 - (c) The concentration of the two gases remains the same.
 - (d) The molecules of the two gases diffuse through the room.
53. Why can we smell any liquid having a distinct odor very fast?
- (a) Because the molecules of the liquid spread into its surrounding space.
 - (b) Because the partition is removed.
 - (c) Because the number of molecules of the liquid is decreased.
 - (d) Because the molecules of the liquid are distributed throughout the bottle.
54. Why do we consider these two happenings the same thing:
- (i) the opening of a bottle of perfume in a closed room,
 - (ii) the placing of a sugar cube in a glass of water?
- (a) Because the molecules of the perfume and those of the sugar both vary from place to place.
 - (b) Because the molecules of the perfume and those of the sugar can form into a homogeneous mixture.
 - (c) Because the molecules of the perfume and those of the sugar can both diffuse into their surrounding space.
 - (d) Because the molecules of the perfume and those of the sugar can both evaporate.
55. What causes the diffusion to occur?
- (a) The difference in the number of molecules of any substance from place to place
 - (b) The space distribution of the molecules of any substance
 - (c) The removal of any partition
 - (d) The decrease of the concentration of any substance
56. What is the writer's purpose in giving us examples in the passage?
- (a) To illustrate a fundamental characteristic of the diffusion process
 - (b) To illustrate the direction of the diffusion of substances
 - (c) To illustrate a fundamental characteristic of the concentration of substances
 - (d) To illustrate a fundamental characteristic of transport phenomena

57. How many kinds of transport phenomena did the writer discuss in the passage?
- (a) none (c) two
(b) one (d) three
58. How did the writer explain the concept of "Molecular diffusion"?
- (a) By first giving the definition
(b) By first presenting some pictures
(c) By first giving some examples
(d) By first asking a reader to give some familiar examples
59. Which was finally discussed in the passage?
- (a) The final illustration on two gases
(b) The direction of the diffusion of the dissolved sugar molecules
(c) The decrease of the concentration of substance
(d) The condition for diffusion to occur
60. What is mainly discussed in the passage?
- (a) Two fundamental characteristics of the diffusion process
(b) The importance of the molecular diffusion
(c) The direction in which the diffusion occurs
(d) The molecular distribution of the liquid

กระดาษคำตอบ
(Answer Sheet)

หมายเลข
(Number) _____

ชื่อ
(Name) _____

คณะ
(Faculty) _____

PASSAGE 1 (P)

PASSAGE 2 (C)

PASSAGE 3 (M)

- | | (a) (b) (c) (d) | | (a) (b) (c) (d) | | (a) (b) (c) (d) |
|-----|-----------------|-----|-----------------|-----|-----------------|
| 1. | () () () () | 21. | () () () () | 41. | () () () () |
| 2. | () () () () | 22. | () () () () | 42. | () () () () |
| 3. | () () () () | 23. | () () () () | 43. | () () () () |
| 4. | () () () () | 24. | () () () () | 44. | () () () () |
| 5. | () () () () | 25. | () () () () | 45. | () () () () |
| 6. | () () () () | 26. | () () () () | 46. | () () () () |
| 7. | () () () () | 27. | () () () () | 47. | () () () () |
| 8. | () () () () | 28. | () () () () | 48. | () () () () |
| 9. | () () () () | 29. | () () () () | 49. | () () () () |
| 10. | () () () () | 30. | () () () () | 50. | () () () () |
| 11. | () () () () | 31. | () () () () | 51. | () () () () |
| 12. | () () () () | 32. | () () () () | 52. | () () () () |
| 13. | () () () () | 33. | () () () () | 53. | () () () () |
| 14. | () () () () | 34. | () () () () | 54. | () () () () |
| 15. | () () () () | 35. | () () () () | 55. | () () () () |
| 16. | () () () () | 36. | () () () () | 56. | () () () () |
| 17. | () () () () | 37. | () () () () | 57. | () () () () |
| 18. | () () () () | 38. | () () () () | 58. | () () () () |
| 19. | () () () () | 39. | () () () () | 59. | () () () () |
| 20. | () () () () | 40. | () () () () | 60. | () () () () |

APPENDIX C

Test of English Grammatical Structures

คำแนะนำ
(Instructions)

ข้อสอบชุดนี้ เป็นข้อสอบที่วัดความเข้าใจของท่านในการอ่านประโยคที่มีโครงสร้างไวยากรณ์ต่าง ๆ กัน มีจำนวนข้อสอบทั้งหมด 45 ข้อ ก่อนที่ท่านจะทำข้อสอบแต่ละข้อ จงอ่านประโยคให้เข้าใจเสียก่อน แล้วจึงอ่านคำถามที่ถามเกี่ยวกับข้อความในประโยคนั้น ๆ แล้วเลือกคำตอบที่เหมาะสมที่สุด 1 คำตอบ โดยทำเครื่องหมาย (X) ที่ข้อ (a) หรือ (b) หรือ (c) หรือ (d) บนกระดาษคำตอบที่จัดไว้

(This test measures your understanding of English grammatical structures. There are 45 items in the test. Read each sentence carefully. Then choose the most appropriate answer for the question. Place the symbol (X) in either the space (a), (b), (c) or (d) on the answer sheet provided.)

ตัวอย่างที่ 1
(Example 1)

Watana is smaller than Wiwat and Lek.

Who is smaller?

- (a) Watana
- (b) None
- (c) Wiwat
- (d) Lek

คำตอบข้อ (a) เป็นคำตอบที่เหมาะสมที่สุด

(The most appropriate answer for the question is (a) .)

ตัวอย่างที่ 2
(Example 2)

Watana is smaller than Wiwat and Lek.

According to the sentence,

- (a) Watana is the smallest.
- (b) Wiwat is the smallest.
- (c) Lek is the smallest.
- (d) All are small.

ข้อ (a) เป็นข้อเลือกที่เหมาะสมที่สุด

((a) is the most appropriate choice.)

ตัวอย่างที่ 3

(Example 3)

Watana is smaller than Wiwat and Lek.

Which of the following sentences best describes the above sentence?

- (a) Watana is the smallest.
- (b) Wiwat is smaller than Watana.
- (c) Lek is smaller than Watana.
- (d) Watana, Wiwat and Lek are small.

ข้อ (a) เป็นคำตอบที่เหมาะสมที่สุด

((a) is the most appropriate answer for the question.)

ข้อสอบชุดนี้เป็นงานส่วนหนึ่งของงานวิจัยระดับปริญญาเอก ซึ่งค้นคว้าเรื่องบทบาทไวยากรณ์ที่มีส่วนต่อความเข้าใจในการอ่านตำราวิทยาศาสตร์ของนักศึกษาไทย โดยเฉพาะความร่วมมือของท่านที่ตั้งใจทำข้อสอบอย่างสุดความสามารถจึงเป็นส่วนสำคัญที่สุดที่จะช่วยให้ผลงานวิจัยนี้ประสบผลสำเร็จตามเป้าหมาย และมีคุณค่าอย่างยิ่งยวดต่อการสอนภาษาอังกฤษแก่นักศึกษาไทยระดับมหาวิทยาลัย

ขอได้รับความขอบคุณจากใจจริงจากผู้วิจัยในการที่ท่านได้ให้ความร่วมมือด้วยดีในครั้งนี้

ศรีปัญญา ใจใหญ่

(This test is part of a Ph.D. research project which sets out to examine the relationship between language structure and reading comprehension of scientific English of Thai science students.

Your cooperation in completing the test to the best of your ability, will be the most important factor in the success of this project. The results will yield great benefit to the teaching and learning of English to Thai students at the university level.

Thank you for your cooperation.

Sripanya Chaiyai)

One can synthesize methyl t-butyl ether from t-butyl chloride by allowing the halide to react with methanol.

(Chem. p.229)

1. Which of the following sentences best describes the above sentence?
 - (a) Methyl t-butyl ether allows t-butyl chloride to react with methanol.
 - (b) T-butyl chloride allows methyl t-butyl ether to react with methanol.
 - (c) One can synthesize methyl t-butyl ether from t-butyl chloride and then allow the halide to react with methanol.
 - (d) One can synthesize methyl t-butyl ether from t-butyl chloride when one allows the halide to react with methanol.

Charge is another coefficient, characteristic of each particle, that determines the strength of its electromagnetic interaction with other particles.

(Physics p.19)

2. What determines the strength of the electromagnetic interaction of one particle with other particles?
 - (a) Charge of each particle
 - (b) The strength of each particle
 - (c) The strength of other particles
 - (d) Characteristic of each particle

A protective horny coat of secreted chitin is found on the skin cells of insects and related groups. Numerous other animals secrete horny protein coats on their outer cells ...

(Bio. p.74)

3. What does "numerous other animals" mean?
 - (a) Numerous animals including insects
 - (b) Numerous animals except insects
 - (c) Only insects and related groups
 - (d) Related groups with horny coats

Biological competition between two different types occupying the same territory often has led to the extinction of one.

(Bio. p.781)

4. According to the sentence,
 - (a) Biological competition occupies the same territory.
 - (b) Two different types often lead to the extinction of one.
 - (c) Biological competition often leads to the extinction of one.
 - (d) Biological competition between two different types occupies the same territory.

The fact that an electric current produces a magnetic field suggests that a single moving charge must also produce a magnetic field.

(Physics p.379)

5. What suggests that a single moving charge must also produce a magnetic field?
- (a) A magnetic field
 - (b) An electric current
 - (c) An electric current produces a magnetic field
 - (d) The fact that there is an electric current

Cenozoic climates played a major role in plant evolution as noted earlier.

(Bio. p.567)

6. According to the sentence, what has been noted earlier?
- (a) Cenozoic climates
 - (b) Plant evolution in cenozoic climates
 - (c) Cenozoic climates' influence on plant evolution
 - (d) Plants in cenozoic climates

These three features will be seen to be the chief features of the halogenation reaction.

(Chem. p.32)

7. According to the sentence, these three features
- (a) are the chief features of the halogenation reaction.
 - (b) will be seen in addition to the chief features of the halogenation reaction.
 - (c) are easy to see.
 - (d) will be seen to be the halogenation reaction.

The magnetic field at points inside a cylinder carrying a current on its surface is zero.

(Physics p.441)

8. What carries a current on its surface?
- (a) A magnetic field
 - (b) A cylinder
 - (c) Points inside a cylinder
 - (d) The magnetic field inside a cylinder

By moving the resonator along the line PQ, Hertz found the position of the nodes and antinodes and the direction of the magnetic field.

(Physics p.683)

9. Which of the following sentences best describes the above sentence?

- (a) Hertz found the position of the nodes and antinodes because he moved the resonator.
- (b) The magnetic field moved the resonator along the line PQ, so Hertz found the position of the nodes and antinodes.
- (c) Hertz found the position of the nodes and antinodes so he moved the resonator.
- (d) Hertz found the position of the nodes and antinodes because the resonator moved the direction of the magnetic field.

In cosmic radiation there are electromagnetic waves of even shorter wavelengths.

(Physics p.579)

10. What do we know about the wavelengths of electromagnetic waves in cosmic radiation and the wavelengths of electromagnetic waves in the other kinds of radiation?

- (a) They are the same.
- (b) They are different.
- (c) They are equally short.
- (d) They are equally long .

We know that men, for example, did not descend "from amoebas" or some other "lower" types.

(Bio. p.29)

11. What do we know?

- (a) Men did not descend from "amoebas" or some other "lower" types.
- (b) "Amoebas" or some other "lower" types are the example of men .
- (c) Men or some other "lower" types did not descend from "amoebas".
- (d) Men who did not descend from amoebas, or some other "lower" types.

Many substances which normally are isotropic become anisotropic when subject to mechanical stresses or to strong static electric or magnetic fields.

(Physics p.629)

12. What become anisotropic substances?

- (a) Most normal substances
- (b) Isotropic substances
- (c) Mechanical stresses
- (d) Magnetic fields

Sun compass mechanisms appear to play some role in navigational guidance during seasonal migrations and in homing.

(Bio. p.438)

13. According to the sentence,

- (a) We are certain that sun compass mechanisms always play their role in navigational guidance.
- (b) When sun compass mechanisms appear they completely control migrations and homing.
- (c) Sun compass mechanisms probably take part in navigational guidance during seasonal migrations and in homing.
- (d) Sun compass mechanisms appear as a guide during migrations and homing.

Because of the negative sign in Equation (16.18), the electric field points in the direction in which the electric potential decreases.

(Physics p.344)

14. The electric field points

- (a) and then the electric potential decreases.
- (b) after the electric potential decreases the direction.
- (c) in the direction of the electric potential.
- (d) in the direction of the decrease of the electric potential.

Many of the simpler carboxylic acids occur widely in nature.

(Chem. p.79)

15. What do we know about "carboxylic acids"?

- (a) There are simple and complex carboxylic acids.
- (b) All carboxylic acids occur widely in nature.
- (c) All simple carboxylic acids occur widely in nature.
- (d) There are only simple carboxylic acids.

We may assume that the protons are clustered around the center of mass of the atom, forming a sort of nucleus, and the electrons are revolving around it, as in our planetary system.

(Physics p.393)

16. In the sentence,

- (a) The protons are clustered around the center of mass of the the atom and the electrons are revolving around it, when an atom is in our planetary system.
- (b) The way which the protons are clustered around the center of mass of the atom, forming a sort of nucleus, is like in our planetary system.
- (c) The system of the atom is thought to be like our planetary system.
- (d) Our planetary system is one example of a system of an atom.

Each carbon of the C=C is converted to a C=O, and any hydrogen attached to these particular carbons is converted to an —OH group.

(Chem. p.40)

17. What is converted to an —OH group?

- (a) Each carbon of the C=C
- (b) Any hydrogen
- (c) The hydrogen of $\begin{array}{c} -C=C- \\ | \\ H \end{array}$
- (d) These particular carbons

An embryonic ovary of a human female is estimated to contain some 400,000 primordial germ cells.

(Bio. p.502)

18. Which of the following sentences best describes the above sentence?

- (a) The human female contains some 400,000 primordial germ cells.
- (b) We guess that the embryonic ovary contains some 400,000 primordial germ cells.
- (c) The embryonic ovary is contained in some 400,000 primordial germ cells.
- (d) We estimate the embryonic ovary in order to let it contain some 400,000 primordial germ cells.

Atmospheric oxygen is the source of the ozone (O_3) layer which envelops the earth at an altitude of some 10 miles.

(Bio. p.212)

19. What surrounds the earth at an altitude of some 10 miles?

- (a) The source of atmospheric oxygen
- (b) All atmospheric oxygen
- (c) The ozone layer
- (d) The source of the ozone layer

Most materials in the physical world actually require activation energies far greater than those energies provided by ordinary temperatures.

(Bio. p.40)

20. According to the above sentence, what play the most important role on most materials in the physical world?

- (a) Energies in the physical world
- (b) Most materials in the physical world
- (c) Energies provided by ordinary temperatures
- (d) Activation energies

The fact that the polarizability of the medium is not the same in all directions means that, in general, the polarization \mathcal{P} does not have the same direction as the electric field ϵ .

(Physics p.626)

21. What explains that the polarization \mathcal{P} does not have the same direction as the electric field ϵ ?
- The differences in all directions of the polarizability of the medium.
 - The different directions of the polarizability of the medium.
 - The same directions of the polarizability of the medium.
 - The differences in the directions between the polarization \mathcal{P} and the electric field ϵ .

The two spatial arrangements represent two different configurational isomers of the same molecular formula.

(Chem. p.133)

22. Which are the same?
- The molecular formulas of two spatial arrangements
 - Two different configurational isomers
 - Two spatial arrangements and two different configurational isomers
 - The molecular formulas of two different configurational isomers

Pressure has far less effect on liquids, which are incompressible and on solids, which may or may not be compressible.

(Bio. p.40)

23. According to the sentence,
- Pressure on liquids is compared with pressure on solids.
 - Pressure on liquids and solids is compared with pressure on something else.
 - Incompressible liquids are compared with compressible solids.
 - Pressure is compared with effect.

The minus sign indicates that the net flow (mass transport) is in the direction in which n (the concentration of the substance) decreases.

(Physics p.284)

24. What does the minus sign indicate?
- The area of greater concentration
 - The direction of the net flow
 - The decrease of the net flow
 - The decrease of the concentration of the substance

By absorbing from and adding to the material in the gut cavity, the large intestine aids in maintaining a properly balanced internal composition of the body.

(Bio. p.301)

25. The large intestine aids in maintaining a properly balanced internal composition of the body _____
- (a) _____ because the large intestine absorbs from and adds to the material in the gut cavity.
 - (b) _____ and later the large intestine absorbs from and adds to the material in the gut cavity.
 - (c) _____ although the large intestine absorbs from and adds to the material in the gut cavity.
 - (d) _____ so a properly balanced composition of the body adds to the material in the gut cavity.

In the IUPAC system the hydroxyl group is treated as a functional group, exactly as was the double bond.

(Chem. p.52)

26. Which of the following sentences best describes the above sentence?
- (a) The hydroxyl group is like the double bond, so it is considered to be a functional group.
 - (b) The hydroxyl group is a functional group, so it is considered to be the double bond.
 - (c) Both the hydroxyl group and the double bond are considered to be functional groups.
 - (d) Because the double bond was a functional group, the hydroxyl group is then a functional group.

The masses of the fundamental particles do not seem to show any kind of regularity.

(Physics p.518)

27. About what are we uncertain?
- (a) The various kinds of the fundamental particles
 - (b) The masses of the fundamental particles
 - (c) Any kind of regularity
 - (d) The regularity of the masses of the fundamental particles

The preceding considerations would suffice to provide a complete analysis of planetary motion if we were to assume that the motion of a planet around the sun was not affected by the other planets and heavenly bodies.

(Physics p.313)

28. What might be assumed not to affect the motion of a planet around the sun?
- (a) All planets including the sun
 - (b) The sun and a planet around the sun
 - (c) All planets excluding the sun
 - (d) The sun

According to the hypothesis of "large" mutations, a major mutation is assumed to transform an organism suddenly, in one jump, to a completely new type.

(Bio. p.544)

29. Which of the following sentences best describes the above sentence?
- (a) A major mutation always transforms an organism suddenly in one jump.
 - (b) We are certain that a major mutation is transformed suddenly to a completely new type.
 - (c) We make an assumption about a major mutation in order to transform an organism to a completely new type.
 - (d) We believe that a major mutation quickly transforms an organism to a completely new type.

In the gut of termites live flagellate protozoa which secrete an enzyme capable of digesting the cellulose of wood.

(Bio. p.105)

30. Flagellate protozoa _____
- (a) are secreted by an enzyme.
 - (b) secrete the cellulose of wood.
 - (c) produce an enzyme.
 - (d) are an enzyme capable of digesting the cellulose of wood.

That the nucleophilicity of Nu^{\ominus} does not necessarily parallel its basicity is evident from the fact that iodide and cyanide ion, which are considerably weaker bases than hydroxide ion, are both stronger nucleophiles.

(Chem. p.222)

31. What is "evident" according to the above sentence?
- (a) The nucleophilicity of Nu^{\ominus} does not necessarily parallel its basicity
 - (b) Its basicity
 - (c) The nucleophilicity of Nu^{\ominus}
 - (d) Nu^{\ominus} does not necessarily parallel its basicity

Most of the observations made on earth are related to a frame of reference attached to it.

(Physics p.81)

32. What are related to a frame of reference?
- (a) Observations which make most things on earth
 - (b) Earth
 - (c) Most of the observations which earth makes
 - (d) Most of the observations which people make on earth

We have already mentioned that indicating the various covalent bonds can be done by using a dash to represent each shared pair of electrons.

(Chem. p.16)

33. What has already been mentioned?
- (a) How the various covalent bonds represent a dash
 - (b) How to use a dash to represent each shared pair of electrons
 - (c) How to use a dash for each shared pair of electrons to indicate the various covalent bonds
 - (d) How to form the various covalent bonds

The energy levels of an atom with several electrons are much more complex than those of atoms with one electron.

(Physics p.602)

34. What are more complex?
- (a) The energy levels of atoms with one electron
 - (b) Atoms with one electron
 - (c) Atoms with several electrons
 - (d) The energy levels of an atom with several electrons

The intramolecular aldol type of condensation is very valuable as a cyclization reaction leading to the formation of five- and six-membered rings.

(Chem. p.360)

35. The intramolecular aldol type of condensation is valuable as a cyclization reaction, because _____

- (a) cyclization reactions lead to the formation of five- and six-membered rings.
- (b) a cyclization reactions leads the intramolecular aldol type of condensation.
- (c) a cyclization reaction leads to the formation of five- and six-membered rings.
- (d) the intramolecular aldol type of condensation leads a cyclization reaction.

Many multicellular organisms have highly specialized sensory cells that are exceedingly sensitive and respond to even weak stimuli.

(Bio. p.22)

36. What are exceedingly sensitive?

- (a) Weak stimuli
- (b) Specialized sensory cells
- (c) Specialized multicellular organisms
- (d) All multicellular organisms

He experiments with some billiard balls by dropping them, and notes that all of them fall with the same acceleration.

(Physics p.324)

37. What are the same?

- (a) The experiments
- (b) The billiard balls
- (c) The dropping of the billiard balls
- (d) The falling speeds of the billiard balls

A fungus is covered by a rigid wall composed of cellulose in primitive types ...

(Bio. p.162)

38. Which of the following sentences best describes the above sentence?

- (a) A rigid wall of a fungus covers cellulose.
- (b) Cellulose is composed of a rigid wall of a fungus.
- (c) A rigid wall of a fungus is composed of cellulose.
- (d) A fungus is composed of cellulose.

IUPAC names of simpler carboxylic acids are still much less frequently used than the common names by which they had been known up to that time.

(Chem. p.79)

39. What are used more often?

- (a) IUPAC names and the common names of simpler carboxylic acids
- (b) The common names of simpler carboxylic acids
- (c) IUPAC names of simpler carboxylic acids
- (d) Simpler carboxylic acids

The various orbitals in which the electrons of an isolated atom may be found are called atomic orbitals.

(Chem. p.10)

40. According to the sentence,

- (a) The electrons of an isolated atom are called atomic orbitals.
- (b) An isolated atom may be found in atomic orbitals.
- (c) The various orbitals of an isolated atom may be found.
- (d) Orbitals of electrons of an isolated atom are called atomic orbitals.

A carbon atom that employs this set of orbitals for bonding is said to have sp^2 hybridization.

(Chem. p.15)

41. According to the sentence,

- (a) Orbitals for bonding have sp^2 hybridization.
- (b) It is said that a type of carbon atom has sp^2 hybridization.
- (c) It is said that a carbon atom employs this set of orbitals for bonding.
- (d) Any carbon atom has sp^2 hybridization.

Nowadays chemists wish to devise syntheses of exotic molecules found in nature.

(Chem. p.462)

42. According to the sentence,

- (a) When chemists devise syntheses, they want syntheses of exotic molecules.
- (b) Chemists want exotic molecules found in nature.
- (c) Chemists devised syntheses of exotic molecules.
- (d) Chemists wish that exotic molecules are found in nature.

The fins of a fish and the arms of a man are basically the same kind of structure.

(Bio. p.27)

43. Which are the same?

- (a) The basic kind of fish and the basic kind of man
- (b) The fins of a fish and the arms of a man
- (c) The structure of a fish and the structure of a man
- (d) The structure of the fins of a fish and the structure of the arms of a man

In general, the different relative strengths by which electrons are attracted to their own nuclei will determine whether two atoms will transfer or share electrons between them.

(Bio. p.60)

44. What will determine whether two atoms will transfer or share electrons between them?

- (a) Their own nuclei
- (b) Electrons attracted to their own nuclei
- (c) The strengths of attraction between electrons and nuclei
- (d) The different general relative strengths of the electrons

There are a number of other reactions of acid derivatives that also involve initial nucleophilic attack on the carbonyl group.

(Chem. p.405)

45. What do we know about the reactions of acid derivatives?

- (a) Many more of the reactions of acid derivatives haven't been mentioned yet.
- (b) There are only reactions of acid derivatives that involve initial nucleophilic attack on the carbonyl group.
- (c) A number of acid derivatives have been mentioned before.
- (d) There are a number of reactions besides the reactions of acid derivatives.

กระดาษคำตอบ
(Answer Sheet)

หมายเลขข้อสอบ _____
(Test Number)

ชื่อ _____
(Name)

คณะ _____
(Faculty)

- | | a | b | c | d | | a | b | c | d |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1. | () | () | () | () | 24. | () | () | () | () |
| 2. | () | () | () | () | 25. | () | () | () | () |
| 3. | () | () | () | () | 26. | () | () | () | () |
| 4. | () | () | () | () | 27. | () | () | () | () |
| 5. | () | () | () | () | 28. | () | () | () | () |
| 6. | () | () | () | () | 29. | () | () | () | () |
| 7. | () | () | () | () | 30. | () | () | () | () |
| 8. | () | () | () | () | 31. | () | () | () | () |
| 9. | () | () | () | () | 32. | () | () | () | () |
| 10. | () | () | () | () | 33. | () | () | () | () |
| 11. | () | () | () | () | 34. | () | () | () | () |
| 12. | () | () | () | () | 35. | () | () | () | () |
| 13. | () | () | () | () | 36. | () | () | () | () |
| 14. | () | () | () | () | 37. | () | () | () | () |
| 15. | () | () | () | () | 38. | () | () | () | () |
| 16. | () | () | () | () | 39. | () | () | () | () |
| 17. | () | () | () | () | 40. | () | () | () | () |
| 18. | () | () | () | () | 41. | () | () | () | () |
| 19. | () | () | () | () | 42. | () | () | () | () |
| 20. | () | () | () | () | 43. | () | () | () | () |
| 21. | () | () | () | () | 44. | () | () | () | () |
| 22. | () | () | () | () | 45. | () | () | () | () |
| 23. | () | () | () | () | | | | | |

APPENDIX D

Test of English Grammatical Structures - Administration

ข้อปฏิบัติในการคุมสอบ Test of English Grammatical Structures

1. กรุณาแจกข้อสอบ และ สมุดคำศัพท์ให้มีหมายเลขตรงกัน และแจกข้อสอบให้เสร็จก่อน น.ศ. เข้าห้องสอบ
โปรดตรวจสอบว่า น.ศ. แต่ละคนได้รับข้อสอบ 2 ชุด คือ 1) Test of English Grammatical Structures และ 2) สมุดคำศัพท์
2. ให้ น.ศ. ทิ้งกระดาษคำตอบ ออกจากแผ่นสุดท้ายของข้อสอบ และให้กรอกทันที
 1. ชื่อ นามสกุล
 2. คณะ
3. ให้ น.ศ. ตรวจสอบข้อสอบ ว่ามี 12 หน้า ไม่นับหน้าปก
4. ให้ น.ศ. คุมสมุดคำศัพท์ และกรอก ชื่อ คณะ ชั้นที่
5. อธิบาย การใช้สมุดคำศัพท์ ดังนี้ เมื่อศึกษาคำใดในข้อสอบ ให้เปิดหาความหมายของคำศัพท์นั้นได้จากสมุดคำศัพท์ แต่ขอให้ วงกลมตัวเลข หน้าคำศัพท์ ที่ต้องการความหมายนั้น ๆ เช่น
 อยากรวมความหมายคำว่า 1. absorb ^{ดูดซึม}
 ก็ให้ทำวงกลม ที่เลข 1 ดังนี้ (1) absorb ^{ดูดซึม}
 ทั้งนี้การวงตัวเลขที่สมุดคำศัพท์ ไม่มีส่วนต่อการพิจารณาคะแนนข้อสอบ
 ให้วงกลมเพื่อประโยชน์แก่การวิจัยส่วนหนึ่งเท่านั้น
6. ให้ น.ศ. เปิดข้อสอบไปที่หน้า "คำแนะนำ"
 อาจารย์คุมสอบ อ่านคำแนะนำ ทั้งหมด ถ้า น.ศ. ไม่เข้าใจให้อธิบายให้ฟัง
 เริ่มทำได้
 มีเวลาทำ 1 ชม. 35 นาที
7. ให้ น.ศ. เขียนชื่อ คณะ หมายเลขข้อสอบ
8. กรุณาตรวจสอบจำนวนกระดาษคำตอบ ข้อสอบ

Test of English Grammatical Structures - Administration

1. Distribute a Test of English Grammatical Structures and a vocabulary list to any desk before the students enter the exam room. Make sure that the code number of the test and the vocabulary list are identical.
Check to see that each student has both the test booklet and the vocabulary list.
2. Ask the students to take the answer sheet out of the back page of the test booklet and write their names and their Faculties.
3. Ask the students to check that their test booklet contained 12 pages of the test items and the test instruction page.
4. Ask them to write their names and Faculties in the space provided on the vocabulary list.
5. Explain how to use the vocabulary list in the following words:

Whenever you face any unfamiliar words in your test booklet, look them up in the vocabulary list. You will get the meaning of the word in Thai. Remember to circle the number which precedes the word you want to look up for its meaning. For example, you want to know what "absorb" means. Look the word "absorb" up in the vocabulary list, you will find ..

1. absorb ๑๑๑๑

Read the meaning and remember to also circle the number which precedes that word:

๑. absorb ๑๑๑๑

Do not be afraid of using the vocabulary list. Putting a circle on a number preceding the word when you want to know the meaning, does not mean that you will lose your mark. The purpose is only for analysis in this study.

6. Ask the students to turn to the instruction page in the test booklet.
Read out loud the test instructions from the test booklet and make sure that every student understands them.

Begin

You have 1 hour and 35 minutes to complete the test.

7. Ask the students to sign their names, Faculties and their test numbers.
8. Check the total number of the test booklets and answer sheets handed in.

APPENDIX EAnswer Key for the Test of English Grammatical Structures

กระดาษคำตอบ
(Answer Sheet)

หมายเลขข้อสอบ _____
(Test Number)

ชื่อ _____
(Name)

คณะ _____
(Faculty)

- | | a | b | c | d | | a | b | c | d |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1. | () | () | () | (X) | 24. | () | (X) | () | () |
| 2. | (X) | () | () | () | 25. | (X) | () | () | () |
| 3. | () | (X) | () | () | 26. | () | () | (X) | () |
| 4. | () | () | (X) | () | 27. | () | () | () | (X) |
| 5. | () | () | (X) | () | 28. | () | () | (X) | () |
| 6. | () | () | (X) | () | 29. | () | () | () | (X) |
| 7. | (X) | () | () | () | 30. | () | () | (X) | () |
| 8. | () | (X) | () | () | 31. | (X) | () | () | () |
| 9. | (X) | () | () | () | 32. | () | () | () | (X) |
| 10. | () | (X) | () | () | 33. | () | () | (X) | () |
| 11. | (X) | () | () | () | 34. | () | () | () | (X) |
| 12. | () | (X) | () | () | 35. | () | () | (X) | () |
| 13. | () | () | (X) | () | 36. | () | (X) | () | () |
| 14. | () | () | () | (X) | 37. | () | () | () | (X) |
| 15. | (X) | () | () | () | 38. | () | () | (X) | () |
| 16. | () | () | (X) | () | 39. | () | (X) | () | () |
| 17. | () | () | (X) | () | 40. | () | () | () | (X) |
| 18. | () | (X) | () | () | 41. | () | (X) | () | () |
| 19. | () | () | (X) | () | 42. | (X) | () | () | () |
| 20. | () | () | () | (X) | 43. | () | () | () | (X) |
| 21. | (X) | () | () | () | 44. | () | () | (X) | () |
| 22. | () | () | () | (X) | 45. | (X) | () | () | () |
| 23. | () | (X) | () | () | | | | | |

APPENDIX F

Talk Given to KKU Science Students

คำชี้แจงให้นักศึกษามหาวิทยาลัยขอนแก่นเพื่อขอความร่วมมือ
ในการทำข้อสอบ ซึ่งเป็นส่วนหนึ่งของงานวิจัย

ก่อนอื่นขอแนะนำตัวเองสักนิดค่ะ คิณช่อ ศรีปัญญา ใจใหญ่ เป็นอาจารย์
ประจำภาควิชาภาษาต่างประเทศ เมื่อประมาณ 3 ปีที่แล้ว ได้ไ้เวลาไปศึกษาต่อที่มหาวิทยาลัย
Massey ประเทศนิวซีแลนด์ งานวิจัยที่สนใจคนคว่าจะเป็นเรื่องเกี่ยวกับทักษะการอ่านตำรา
วิทยาศาสตร์ที่เป็นภาษาอังกฤษของนักศึกษาไทย โดยเฉพาะที่มหาวิทยาลัยขอนแก่น ขณะนี้คิณ
มีโอกาสกลับมาเมืองไทยเพื่อรวบรวมข้อมูล ซึ่งหมายถึง คะแนนที่จะได้จากการสอบข้อสอบ
ภาษาอังกฤษ 4 ชุด ของนักศึกษามหาวิทยาลัยขอนแก่น แล้วคิณจะนำข้อมูลที่ได้นี้กลับไป
นิวซีแลนด์ เพื่อวิเคราะห์ต่อไป

เนื่องจากว่าพวกคุณเป็นกลุ่มนักศึกษาที่ได้รับการคัดเลือกให้เข้ารับการทดสอบ
(ด้วยวิธีการจับฉลาก) คิณจึงขอถือโอกาสขอความร่วมมือจากพวกคุณเป็นพิเศษกรุณาสละเวลา
อันมีค่าของพวกคุณเพื่อเข้ารับการทดสอบ 4 ครั้งติดต่อกันด้วยความร่วมมือของพวกคุณครั้งนี้จะเป็น
ส่วนสำคัญช่วยให้งานวิจัยชิ้นนี้สำเร็จลุล่วงไปด้วยดี ทั้งจะยังมีผลสะท้อนถึงการปรับปรุงการเรียน
การสอนภาษาอังกฤษ อันจะยังผลประโยชน์แก่นักศึกษามหาวิทยาลัยขอนแก่นในอนาคตด้วย

อนึ่ง ในการเข้ารับการทดสอบข้อสอบครบทั้ง 4 ชุดนั้นนักศึกษาจะได้รับเงิน
สมนาคุณคนละ 35 บาท ทั้งมีเงินรางวัล ๆ ละ 50 บาท มอบให้แก่ผู้ที่สามารถทำข้อสอบ
แต่ละชุด ได้คะแนนสูงสุดอีกด้วย

วันและสถานที่สอบมีดังนี้

วันอาทิตย์	22 ก.ค.	เวลา 9.30 - 12.00
		เวลา 13.30 - 15.30
วันพฤหัสบดี	26 ก.ค.	เวลา 19.00 - 21.00
วันจันทร์	30 ก.ค.	เวลา 19.00 - 21.00

นักศึกษาคณะเกษตรศาสตร์	สอบท	ติทวงกลมทอง	101
นักศึกษาคณะพยาบาล	สอบท	ติทวงกลมทอง	102
นักศึกษาคณะวิทยาศาสตร์ และศึกษาศาสตร์	สอบท	ติทวงกลมทอง	103

สุดท้ายนี้ ขอให้นักศึกษาที่ยินดีให้ความร่วมมือเข้าสอบลงลายมือชื่อ และจกสถานที่อยู่
ลงในกระดาษรายชื่อที่เตรียมไว้ให้

ขอบคุณมากคะ

Talk Given to KKU Science Students

First of all let me introduce myself. I am Miss Sripanya Chaiyai, a lecturer from the Department of Foreign Languages, Khon Kaen University. I left the Department three years ago to complete further studies at Massey University, New Zealand. My research work involves reading comprehension of Thai science students, particularly students at Khon Kaen University. I have the opportunity to return here to administer four tests, collect the data and take them to New Zealand for further analysis.

Some of you have been randomly selected as subjects for my study. I would like to take this occasion to ask those who have been selected for my study to devote their precious time to willingly taking the four tests. The success of my project depends on your cooperation. The results of my study will yield a valuable information which will improve the teaching and learning of English at Khon Kaen University.

For taking part in the project, each student will receive 35 Baht. Those students who score the highest mark on each test will also receive a special award of 50 Baht each.

Exam schedules are as follows:

Sunday, July 22	9.30 - 12.00 a.m.
	1.30 - 3.30 p.m.
Thursday, July 26	7.00 - 9.00 p.m.
Monday, July 30	7.00 - 9.00 p.m.

Exam rooms:

Room 101 for Agricultural students
 Room 102 for Medical and Nursing students
 Room 103 for Science and Education students

Finally, if you are willing to take part in this project, please sign your name and write your address on the form provided.

Thank you.

APPENDIX G

Letter to KKU Science Students

บันทึกข้อความ

ส่วนราชการ ภาควิชาภาษาต่างประเทศ

ที่ ทม.๐๕๐๘(๕) /

วันที่

กรกฎาคม ๒๕๖๒

เรียน _____

ดิฉัน ศรีปัทมา ใจใหญ่ อาจารย์ประจำภาควิชาภาษาต่างประเทศ ซึ่งกำลังทำปริญญาเอก สาขาการสื่อสารภาษาอังกฤษ อยู่ประเทศนิวซีแลนด์ ในเรื่องเกี่ยวกับ การศึกษาทักษะการอ่านตำราวิทยาศาสตร์ ที่เป็นภาษาอังกฤษของนักศึกษามหาวิทยาลัยขอนแก่น โดยเฉพาะ และขณะนี้ได้รับอนุมัติให้กลับมาเก็บข้อมูล อยู่ในประเทศไทยนั้น มีความประสงค์ที่จะขอได้รับความร่วมมือจากคุณเป็นอันมาก ในการเข้ารับการทดสอบ ทดสอบภาษาอังกฤษ ๔ ชุด ดังเวลาดังนี้.

ชุดที่ ๑	วันอาทิตย์ที่ ๒๒	กรกฎาคม	เวลา ๘.๓๐ - ๑๒.๐๐
ชุดที่ ๒	"	๒๒	กรกฎาคม เวลา ๑๓.๓๐ - ๑๕.๓๐
ชุดที่ ๓	วันพฤหัสบดีที่ ๒๒	กรกฎาคม	เวลา ๑๘.๐๐ - ๒๑.๐๐ (กลางวัน)
ชุดที่ ๔	วันจันทร์ที่ ๓๐	กรกฎาคม	เวลา ๑๘.๐๐ - ๒๑.๐๐ (กลางวัน)

ห้องสอบ ที่ทางคณะกรรมการฯ ศึกษาศาสตร์ ห้อง _____

ทั้งนี้คุณจะได้รับเงินสมนาคุณจำนวน ๓๕ บาท ที่กรุณาให้ความร่วมมือเข้ารับการทดสอบ ครบทั้ง ๔ ชุด (จะขาดชุดหนึ่งชุดใดไม่ได้ ด้วยเหตุผลที่ว่า ข้อมูลจะนำมาใช้ไม่ได้เลย) อนึ่ง มีเงินรางวัลพิเศษสำหรับผู้ที่ทำคะแนนได้สูงสุดในแต่ละข้อสอบและในแต่ละคณะ

ดิฉันหวังในความร่วมมือจากคุณเป็นอย่างยิ่ง

ขอขอบคุณล่วงหน้า
ศรีปัทมา ใจใหญ่

กรุณาฉีกกระดาษส่วนนี้ นำส่ง อ. ศรีปัทมา ใจใหญ่ ภาควิชาภาษาต่างประเทศ มหาวิทยาลัยขอนแก่น ภายในวันอังคารที่ ๑๗ กรกฎาคม เป็นอย่างช้าะคะ

(กรุณาลงลายมือชื่อเข้ารับการทดสอบ).

ถ้าติดกลับมาไม่ได้ กรุณาแจ้ง จะเป็นพระคุณยิ่งคะ

Department of Foreign Languages

Ref. 0508(5)/

July __, 1979.

Dear _____

I am conducting a research project for my Ph.D. studies in New Zealand on reading comprehension of Thai science students. I have returned to Thailand to collect the data. Your kind cooperation in taking the tests at the following time will be most appreciated.

Test 1	Sunday, July, 22	9.30 - 12.00 a.m.
Test 2	Sunday, July 22	1.30 - 3.30 p.m.
Test 3	Thursday, July 26	7.00 - 9.00 p.m.
Test 4	Monday, July 30	7.00 - 9.00 p.m.

Your exam room number will be _____.

For taking the tests, you will receive 35 Baht (attendance at all four sessions is necessary).

By the way, there is an award for those who receive the highest scores for each test, in each Faculty.

Hoping for your kind cooperation.

Thank you.

Sripanya Chaiyai

Tear this part of the letter off and mail it to Miss Sripanya Chaiyai, Department of Foreign Languages by July 17 at the latest.

(Sign your name here)

(Reasons for not being able to take the tests.)

APPENDIX H

Cloze Reading Comprehension Test - Administration

ข้อปฏิบัติในการคุมสอบ Cloze Reading Comprehension Test

1. ข้อสอบมี 3 ฟอร์มซึ่งแตกต่างกันเฉพาะการเรียงลำดับเรื่องเท่านั้น สิ่งแรกฟอร์มข้อสอบได้จากหมายเลขหน้าปกข้อสอบ

ข้อสอบที่มีหมายเลขขึ้นต้นคล้าย	1	เช่น	101	=	ฟอร์ม	1		
"	"	"	2	เช่น	232	=	ฟอร์ม	2
"	"	"	3	เช่น	351	=	ฟอร์ม	3

กรุณาแจกข้อสอบให้เสร็จก่อน น.ศ. เข้าห้องสอบ โดยแจกข้อสอบให้สลับกัน
ดังตัวอย่าง

แถวที่	1	Form	1	Form	2	Form	3
แถวที่	2	"	2	"	3	"	1
แถวที่	3	"	3	"	1	"	2

2. เมื่อ น.ศ. เข้าห้องสอบแล้ว ห้าม น.ศ. เปิดข้อสอบจนกว่าจะได้รับอนุญาต ขอร้องให้ น.ศ. ปฏิบัติตามอย่างเคร่งครัด
3. ให้ น.ศ. ทิ้งกระดาษคำตอบออกจากหน้าสุดท้ายของข้อสอบ แล้วให้ น.ศ. กรอกข้อความทันที คือ
1. ชื่อ นามสกุล
 2. คณะ
- โทษแจ้ง น.ศ. ดังนี้ "กรุณาใช้ชื่อจริง เพราะข้อมูลที่ได้จาก น.ศ. ครั้งนี้จะนำไปใช้ประโยชน์สำหรับงานวิจัยเท่านั้น และจะรักษาไว้เป็นความลับ ทางมหาวิทยาลัย หรือภาควิชาภาษาต่างประเทศไม่มีส่วนเกี่ยวข้องกับข้อมูลนี้เลย"
4. ให้อธิบาย น.ศ. ดังนี้ "การทำข้อสอบชุดนี้ เป็นการทดสอบความสามารถในการอ่านตำราวิทยาศาสตร์ ขอให้ น.ศ. ทำด้วยความตั้งใจและทำอย่างสุดความสามารถ"

และให้ทำข้อสอบหมดครบทั้ง 3 ข้อ โดยทำเรื่องไปตามลำดับจากเรื่องแรกไปถึงเรื่องหลัง จะให้เวลาทำเรื่องละ 45 นาที ทั้งนี้อาจารย์จะเป็นผู้บอกเวลาให้ทุก ๆ 45 นาที น.ศ. คนใดทำเรื่องแรกเสร็จก่อนเวลา ให้ทำเรื่องต่อไปได้"

5. "น.ศ. คนใดมีข้อสอบที่มีกระดาษเปล่าคั่นอยู่ ไม่ต้องแปลกใจให้พลิกหน้าไปจนพบเรื่องต่อไป"
6. "เมื่อทำข้อสอบเสร็จ ให้สอดกระดาษคั่นคอบไว้ในข้อสอบ และวางทิ้งไว้บนโต๊ะ"
7. "ต่อไปนี้ให้ น.ศ. เปิดข้อสอบไปที่หน้า "ตัวอย่าง" และดูที่เรื่อง Our school จะเห็นว่ามีคำขาดหายไป 3 คำ น.ศ. ต้องหาคำที่เหมาะสมมาเติมลงในช่องว่าง ซึ่งเมื่อ อ่านแล้วได้ใจความที่ ทั้งนี้ช่องว่างแต่ละช่องจะเติมคำได้เพียง คำเดียว เท่านั้น"

ตัวอย่าง : ก่อนทำข้อสอบเรื่อง Our school ให้อ่านเรื่องให้ตลอดเสียก่อน เพื่อเดาเอาว่าจะเป็นเรื่องเกี่ยวกับอะไร เช่น Boys / girls go to our school.

At / we learn to read. We also learn how/ write แล้วอ่านใหม่ คราวนี้ คิดค้นคำที่จะเอามาเติมในช่องว่าง ก็จะได้ Boys and girls. ให้ น.ศ. ทุกคนเขียนคำ

and ลงบนกระดาษคำตอบ ข้อ 1 ในกรอบตัวอย่าง Boys and girls go to our school.

At (2) ให้ น.ศ. เถาคำและเขียนคำนั้นลงบนกระดาษคำตอบ ข้อ 2

เฉลย At school we learn to read. We also learn how (3) write ของ เขียนคำที่

3 ลงบนกระดาษคำตอบ ก็จะได้คำ to

ต่อไปนี้ให้ลองทำเรื่อง The Count-Down เกมคำที่ 4, 5, 6, 7, 8 ลงบนกระดาษคำตอบ (ให้เวลาทำ 3 นาที)

เฉลย

คำที่	4	-	seven
	5	-	two
	6	-	the
	7	-	it
	8	-	see

ถาม ใครไม่เข้าใจ (ให้โอกาสซัก และอธิบายให้เข้าใจ) กล่าวยั่วว่า "จะเห็นว่า คำที่เราหามาเติมในช่องว่างแต่ละช่องจะเป็นคำอะไรก็ได้ แต่ต้องเป็น คำเดียว และเมื่อเติมลงไปประโยคแล้วได้ใจความควย

ขอให้เติมคำในกระดาษคำตอบ ทุกข้อ ถ้ามีไม่ออกให้ เดา เอา "

เริ่มทำได้

8. อาจารย์คุมสอบกรุณาจับเวลา และจดเวลาให้ น.ศ. ทราบเมื่อเวลาผ่านไป 45 นาที แรกแล้ว เพื่อให้ น.ศ. มีโอกาสทำข้อสอบเรื่องต่อไป
9. ให้ น.ศ. ทุกคนเซ็นชื่อ คณะ และหมายเลขข้อสอบ
10. ไปรกรวดสอบให้แน่ชัด ก่อนเก็บข้อสอบและกระดาษคำตอบ ว่ามีชื่อ น.ศ. และ คณะ อยู่บนกระดาษคำตอบ
11. กรุณาแยก กระดาษคำตอบ ของแต่ละคณะ ออกจากกัน
12. กรุณาแยก ฟอร์มทั้ง 3 ของแต่ละคณะออกจากกัน
13. ตรวจสอบ ข้อสอบให้ครบ
14. ตรวจสอบจำนวน กระดาษคำตอบ และจำนวน น.ศ. ที่เข้าสอบ

Cloze Reading Comprehension Test - Administration

1. The test was prepared in three different forms. The forms can be distinguished by the number at the initial position of the test number.

Test number 101 = Form 1

Test number 232 = Form 2

Test number 351 = Form 3

2. Tell the students not to open the test booklet until they are told to do so.
3. Ask the students to take the answer sheet out of the back page of the test booklet and to write their names and their Faculties in the space provided. Say the following words:

Use your real name. Your scores will be confidential. They will be used only for this study. The university or the Department of Foreign Languages will not be allowed to have access to them.

4. Then explain in the following words:

This test is to measure your reading comprehension of scientific English passages. Complete the test to the best of your ability. Complete the test in order from beginning to end. Only 45 minutes is allowed for each passage.

5. Do not be surprised to find a blank page in your test booklet.
6. Leave your test booklet and the answer sheet on the desk when you have completed the test.
7. Say the following words:

Turn to the example page. Notice that three words are missing from the story "Our school." You are required to fill in these three blank spaces with the words which are appropriate to the context. You must fill in only one word for each blank. To complete the test, it is suggested you read the

whole story first. The reason is for you to guess what the passage is about. Then try to fill in the blanks with the appropriate words. For example, read the story like this: "Boys/girls go to our school. At/ we learn to read. We also learn how/ write." Then read the story again, this time you have to try to fill in the blank with the word which you think is the most appropriate to the context. Now, fill in the first blank (Here the lecturer pauses one moment for the students to fill in the first blank). Now let's check the correct answer. The appropriate word for the first blank is and. Boys and girls go to our school. Now complete the rest of the story (Here the lecturer pauses for one minute). The appropriate words for the second and the third blanks are school and to. Next, let's practise more on the story "The Count-down." This time fill in the blanks on the answer sheet.

After 3 minutes, the lecturer said the following words:

The appropriate answers for the story "The Count-down" are: seven, two, the, it, see.

Then emphasize the following words:

Remember, fill in only one word for each blank. The word should also fit in the context. Fill in every blank. Make a guess if you can not think of one.

Begin

8. Let the students know the time.
9. Ask the students to sign their names, Faculties and their test numbers.
10. Make sure that every student signs their names and Faculties on the answer sheet.
11. Group the answer sheets according to the Faculty.

12. Group the test booklets according to their form.
13. Finally after the test, check the total number of the test booklets.
14. Also check the total number of the students taking the test against the total number of the answer sheets.

APPENDIX IAnswer Key for the Cloze Reading Comprehension Test

(Exact Word Responses)

PARASITIC REPRODUCTION	COVALENT BONDS	TRANSPORT PHENOMENA
1. parasite	1. a	1. a
2. stage	2. to	2. other
3. by	3. a	3. as
4. last	4. shared	4. quickly
5. quite	5. the	5. room
6. or	6. hydrogen	6. the
7. of	7. hydrogen	7. air
8. of	8. electrons	8. The
9. Entering	9. an	9. a
10. of	10. pair	10. water
11. directly	11. Despite	11. the
12. and	12. by	12. diffuse
13. anus	13. act	13. distributed
14. The	14. both	14. illustration
15. passive	16. purposes	15. a
16. man	16. for	16. and
17. can	17. may	17. gases
18. However	18. electrons	18. a
19. pyramids	19. other	19. mixture
20. man	20. bonds	20. to
21. A	21. to	21. of
22. thus	22. to	22. the
23. if	23. its	23. the
24. are	24. forms	24. Let
25. to	25. covalent	25. molecules
26. by	26. of	26. volume
27. of	27. the	27. of
28. into	28. other	28. statement
29. through	29. outer	29. to
30. blood	30. of	30. occur

APPENDIX J

Answer Key for the Cloze Reading Comprehension Test

(Acceptable Word Responses)

PARASITIC REPRODUCTION

- | | |
|------------------------------------|---|
| 1. parasite | 16. man |
| 2. stage, phase, period | 17. can, do, will, could |
| 3. by, or | 18. However, The, So,
But, These |
| 4. last, hosts | 19. pyramids, chain, cycle |
| 5. quite, really,
comparatively | 20. man |
| 6. or, and, by | 21. A, The, This, That |
| 7. of | 22. thus, therefore, then,
now, always, usually, still |
| 8. of | 23. if |
| 9. Entering, Passing | 24. are |
| 10. of | 25. to |
| 11. directly | 26. by |
| 12. and, then, but | 27. of |
| 13. anus | 28. into |
| 14. The, Their | 29. through |
| 15. passive | 30. blood |

COVALENT BONDS

- | | |
|-------------------------|--|
| 1. a, the | 16. for |
| 2. to | 17. may, can, could,
will, would, shall |
| 3. a, one | 18. electrons |
| 4. shared | 19. other |
| 5. the | 20. bonds |
| 6. hydrogen, the, this | 21. to |
| 7. hydrogen | 22. to |
| 8. electrons | 23. its, the |
| 9. an, one | 24. forms |
| 10. pair | 25. covalent |
| 11. Despite | 26. of |
| 12. by, between | 27. the |
| 13. act | 28. other, hydrogen, four |
| 14. both, hydrogen, two | 29. outer, outermost |
| 15. purposes, need | 30. of |

TRANSPORT PHENOMENA

1. a
2. other
3. as
4. quickly, rapidly, fast
5. room, area, space, place
6. the, this, that, ammonia
7. air
8. The
9. a
10. water
11. the
12. diffuse, spread
13. distributed, found, spread
14. illustration, example
15. a, one
16. and, then, when, as, after
17. gases
18. a
19. mixture
20. to
21. of
22. the
23. the, a, any
24. Let
25. molecules
26. volume
27. of
28. statement, sentence
29. to
30. occur, happen

APPENDIX K

Multiple-choice Reading Comprehension Test - Administration

ข้อปฏิบัติในการคุมสอบข้อสอบ

Multiple-choice Reading Comprehension Test

1. ข้อสอบชุดนี้มี 3 พอร์ม สังเกตได้จากหมายเลขข้อสอบ ดังนี้

พอร์ม 1	<u>101</u>
พอร์ม 2	<u>232</u>
พอร์ม 3	<u>351</u>

 กรุณาแจกข้อสอบทั้ง 3 พอร์ม สลับกันไป
2. ห้ามนักศึกษาเปิดข้อสอบก่อนได้รับอนุญาต
3. ให้นักศึกษาตรวจสอบดูจำนวนหน้าข้อสอบให้ครบถ้วน
4. ให้นักศึกษาตั้งกระดาษคำตอบออกจากแผ่นสุดท้ายของข้อสอบ แล้วกรอกชื่อ และ คณะให้เรียบร้อย
5. เมื่อนักศึกษาทำข้อสอบเสร็จแล้ว ให้นำข้อสอบและกระดาษคำตอบส่งอาจารย์คุมสอบ
6. ให้นักศึกษารับข้อสอบแปล ไปทำต่อจนจบ
7. มอบซองเงินจำนวน 35 บาท ให้นักศึกษาแต่ละคน พร้อมทั้งให้นักศึกษาเซ็นชื่อรับเงินด้วย
8. พูดว่า "ต่อไปนี่ ขอให้ดูที่ข้อสอบ มีให้อ่าน 3 เรื่อง ให้นำข้อสอบเรียงไปตามลำดับจากเรื่องแรกจนถึงเรื่องสุดท้าย มีเวลาทำเรื่องละ 45 นาที ต่อไปนี้ ให้เปิดข้อสอบไปที่หน้า "คำแนะนำ"
(อาจารย์คุมสอบ กรุณาอ่าน "คำแนะนำ" ด้วย)

ศรัปัญญา ใจใหญ่

Multiple-choice Reading Comprehension Test - Administration

1. Notice that there are three forms of the test:

Form 1 as in the test number 101

Form 2 as in the test number 232

Form 3 as in the test number 351

Distribute the three forms of the test alternatively.

2. Tell the students not to open the test booklet until they are told to do so.
3. Ask the students to check the number of the pages of the test.
4. Ask the students to take the answer sheet out of the back page of the test booklet and to write their names and their Faculties in the space provided.
5. Ask the students to hand in the test booklet and the answer sheet to their proctor when the test is completed.
6. Ask the students to complete the English-Thai Translation Test.
7. Give each student an envelope of 35 Baht and ask him to sign his name.
8. Say the following words:

You have 45 minutes for each reading passage.

The test contains three passages. Please complete them all. Take the test in order as set at the test booklet. Now turn to the instruction page.

Read out loud the instructions

Miss Sripanya Chaiyai

APPENDIX L

Answer Key for the Multiple-choice Reading Comprehension Test

กระดาษคำตอบ
(Answer Sheet)

หมายเลข
(Number)

ชื่อ
(Name)

คณะ
(Faculty)

PASSAGE 1 (P)

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| 1. | (X) | () | () | () |
| 2. | (X) | () | () | () |
| 3. | () | () | () | (X) |
| 4. | () | () | (X) | () |
| 5. | () | () | (X) | () |
| 6. | () | (X) | () | () |
| 7. | () | () | () | (X) |
| 8. | () | (X) | () | () |
| 9. | () | () | (X) | () |
| 10. | () | (X) | () | () |
| 11. | () | () | (X) | () |
| 12. | (X) | () | () | () |
| 13. | () | () | () | (X) |
| 14. | (X) | () | () | () |
| 15. | () | () | () | (X) |
| 16. | (X) | () | () | () |
| 17. | () | () | (X) | () |
| 18. | () | (X) | () | () |
| 19. | () | () | () | (X) |
| 20. | () | (X) | () | () |

PASSAGE 2 (C)

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| 21. | () | () | () | (X) |
| 22. | (X) | () | () | () |
| 23. | (X) | () | () | () |
| 24. | () | () | (X) | () |
| 25. | () | () | () | (X) |
| 26. | () | () | (X) | () |
| 27. | () | (X) | () | () |
| 28. | () | () | () | (X) |
| 29. | (X) | () | () | () |
| 30. | () | () | () | (X) |
| 31. | () | () | () | (X) |
| 32. | () | () | (X) | () |
| 33. | (X) | () | () | () |
| 34. | (X) | () | () | () |
| 35. | () | (X) | () | () |
| 36. | () | (X) | () | () |
| 37. | () | (X) | () | () |
| 38. | () | () | (X) | () |
| 39. | () | (X) | () | () |
| 40. | () | () | (X) | () |

PASSAGE 3 (M)

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| 41. | () | () | () | (X) |
| 42. | (X) | () | () | () |
| 43. | () | (X) | () | () |
| 44. | () | () | () | (X) |
| 45. | () | () | (X) | () |
| 46. | () | () | () | (X) |
| 47. | () | () | (X) | () |
| 48. | () | () | () | (X) |
| 49. | () | (X) | () | () |
| 50. | () | (X) | () | () |
| 51. | () | () | (X) | () |
| 52. | () | (X) | () | () |
| 53. | (X) | () | () | () |
| 54. | () | () | (X) | () |
| 55. | (X) | () | () | () |
| 56. | (X) | () | () | () |
| 57. | () | (X) | () | () |
| 58. | () | () | (X) | () |
| 59. | () | () | () | (X) |
| 60. | (X) | () | () | () |

APPENDIX M

Multiple-choice Reading Comprehension Test - Test Item Statistics¹

Item	RPB	Diff	Item	RPB	Diff
1	235	300	31	286	642
2	291	263	32	306	352
3	286	763	33	029	289
4	263	552	34	170	315
5	393	268	35	245	536
6	281	600	36	288	436
7	274	852	37	096	536
8	026	184	38	200	515
9	292	736	39	203	494
10	282	500	40	183	552
11	260	642	41	246	473
12	193	489	42	014	321
13	259	747	43	131	396
14	147	557	44	344	500
15	248	573	45	344	584
16	262	531	46	414	384
17	317	210	47	263	626
18	377	615	48	294	663
19	235	400	49	146	494
20	186	594	50	174	263
21	242	421	51	242	621
22	165	363	52	081	542
23	278	410	53	386	421
24	268	442	54	417	473
25	195	457	55	335	700
26	133	373	56	272	478
27	358	563	57	145	389
28	106	378	58	174	378
29	324	215	59	137	673
30	426	526	60	101	200

¹ Decimal points omitted

RPB = point-biserial correlation

Diff = difficulty index

APPENDIX N

Correct Response Lengths in the Multiple-choice
Reading Comprehension Test

Length of the Correct Response	Passage			Total
	1	2	3	
	Covalent Bonds	Molecular Diffusion	Parasitic Reproduction	
The shortest response is the correct answer.	Items 24, 40	Item 45	Items 4, 6, 15, 18, 19	8
The longest response is the correct answer.	Items 31, 33, 34, 35, 38	Items 51, 52, 54, 55, 60	Items 13, 20	12
The response of intermediate length is the correct answer.		Item 46	Item 1	2
The correct answer is one of the two response choices both of which are the same length but shorter than the other two responses of the item.	Items 26, 30, 32, 36	Items 58, 59		6
The correct answer is one of the two responses both of which are the same length but longer than the other two responses to the item.	Items 22, 37, 39	Items 47, 48, 53	Items 2, 5, 9, 11, 12, 17	12

APPENDIX O

Vocabulary List

คำศัพท์
(Vocabulary)

หมายเลข _____
(Number)

ชื่อ _____
(Name)

คณะ _____
(Faculty)

- | | |
|----------------------|---|
| 1. absorb | ดูดซึม |
| 2. acceleration | ความเร่ง |
| 3. acetal | สารอาซีเทิล |
| 4. acid | กรด |
| 5. activation | การกระตุ้น |
| 6. actually | เป็นความจริง |
| 7. add to | เพิ่มเข้าไป |
| 8. affect | มีผลต่อ |
| 9. aid | ช่วย |
| 10. aldol | สารประกอบ แอลดอล |
| 11. altitude | ระยะสูงเหนือระดับน้ำทะเล |
| 12. amine | สารอามีน |
| 13. analysis | การวิเคราะห์ |
| 14. analyze | วิเคราะห์ |
| 15. anisotropic | ซึ่งมีคุณสมบัติทางกายภาพต่างกัน ในแกนที่ต่างกัน |
| 16. antinode | ปฏิภาค |
| 17. appear | ปรากฏ, ดูเหมือน |
| 18. arrangement | การเรียงตัว |
| 19. assume | สันนิษฐาน |
| 20. atmospheric | ในบรรยากาศ |
| 21. atom | อะตอม |
| 22. attach to | เชื่อม |
| 23. attract | ดึงดูด |
| 24. bacterial action | การกระทำของจุลินทรีย์ |

25. basically	โดยพื้นฐาน
26. basicity	สภาพด่าง
27. behavior	พฤติกรรม
28. billiard ball	ลูกบิลเลียด
29. biological	ทางชีววิทยา
30. bond	พันธะ (การเกาะกันของอะตอม)
31. capable	ที่สามารถ
32. capture	จับ
33. carbon	คาร์บอน
34. carbonyl	คาร์บอนิล
35. carboxylic	คาร์บอกซิลิก
36. carrier	ตัวนำ
37. cavity	ช่องว่าง
38. cellulose	เซลลูโลส (โพลิแซ็กคาไรด์ สารประกอบคาร์โบไฮเดรต)
39. center	ศูนย์กลาง
40. cenozoic	สมัยทีโมโซอิก
41. characteristic	ลักษณะเฉพาะตัว
42. charge	ประจุ
43. chitin	ไคติน (เรียกหมีสัตว์) เป็นสารที่แข็งเหนียว
44. chlorophyll	คลอโรฟิลล์
45. chloroplast	คลอโรพลาสต์ (เซลล์พืชที่มีคลอโรฟิลล์สีเขียว)
46. cluster	เกาะกันเป็นกลุ่ม
47. coat	ผิวนอก
48. coefficient	สัมประสิทธิ์
49. colon	ลำไส้ใหญ่
50. compass	เข็มทิศ
51. competition	การแข่งขัน
52. complex	ซับซ้อน ยุ่งยาก
53. composition	ส่วนประกอบ
54. compose of	ประกอบด้วย

55. compressible	บีบอัดได้
56. concentration	ความหนาแน่น
57. condensation	ปฏิกิริยาการควบแน่น
58. condition	สภาวะ
59. configurational isomer	สาร ไอโซเมอร์ ที่มีการจัดเรียงตัวของอะตอม
60. considerably	มาก ในโมเลกุล ต่างกัน
61. consideration	การพิจารณา
62. contribution	การมีส่วนร่วมช่วยเหลือ
63. convert to	เปลี่ยนไป
64. cosmic radiation	รังสีคอสมิก
65. covalent bond	พันธะโควาเลนต์
66. cover	ปกคลุม
67. critical	ที่สำคัญ
68. curve	เส้นโค้ง
69. cyanide ion	ไซยาไนด์ ไอออน
70. cyclization reaction	ปฏิกิริยาที่ทำให้เกิดโครงสร้างรูปวงแหวน
71. cylinder	กระบอก
72. dash	เครื่องหมายขีด
73. decrease	ลดลง
74. derivative	อนุพันธ์
75. descend	สืบลงมา
76. determine	กำหนด, ตัดสิน
77. develop	เจริญพัฒนา
78. devise	คิดประดิษฐ์
79. diffuse	กระจาย
80. digest	ย่อย
81. dim	จมุกขมัว
82. direction	ทิศทาง
83. double bond	พันธะคู่
84. drop	ทิ้ง

85. due to	ขึ้นอยู่กับ
86. earlier	ก่อนหน้านี้
87. effect	ผล
88. electric current	กระแสไฟฟ้า
89. electric field	สนามไฟฟ้า
90. electric potential	ศักย์ไฟฟ้า
91. electromagnetic	แม่เหล็กไฟฟ้า
92. electron	อิเล็กตรอน
93. embryonic	ระยะตัวอ่อน
94. ensure	ทำให้มั่นใจ
95. envelop	ห่อหุ้ม
96. enzyme	เอนไซม์ (เอนไซม์)
97. equilibrium	การสมดุล
98. estimate	ประมาณ
99. evident	เห็นชัดแจ้ง
100. evolution	การวิวัฒนาการ
101. exceedingly	เหลือเกิน
102. excess	จำนวนที่เกินพอ
103. exotic	แปลก
104. experiment (v)	ทดลอง
105. extinction	สูญพันธุ์
106. familiar	คุ้นเคย
107. feature	คุณลักษณะ
108. female	เพศหญิง
109. fern	เฟิร์น
110. fin	ครีบ
111. flagellate	หนวด
112. form	รวมกันเป็น
113. formation	การก่อตัว
114. frame of reference	ระบบอ้างอิง

115.	frequently	บ่อย ๆ
116.	functional group	หมู่ที่จะทำปฏิกิริยา
117.	fundamental	มูลฐาน
118.	fungus	เห็ดรา (ฟังกัส)
119.	germ cell	เซลล์สืบพันธุ์
120.	guidance	การนำทาง
121.	gut	ทางเดินอาหาร
122.	halide	เฮไลด์
123.	halogenation reaction	ปฏิกิริยา เฮโลเจเนชัน
124.	heavenly bodies	วัตถุในจักรวาล
125.	highly	มาก
126.	homing	กลับบ้าน
127.	horizontal	ตามแนวราบ
128.	horny	แข็ง เหนียว
129.	hybridization	ไฮบริไดเซชัน
130.	hydroxyl group	หมู่ไฮดรอกซิล
131.	hypothesis	ข้อสมมติฐาน
132.	incompressible	ซึ่งอัดไม่ได้
133.	indicate	ชี้ให้เห็น
134.	inherited	รับช่วง
135.	initial	เริ่มกัน
136.	interaction	อันตรกิริยา
137.	intersection	จุดกั๊ก
138.	intestine	ลำไส้
139.	intramolecular	ลักษณะการ เกาะกันภายในโมเลกุลเดียวกัน
140.	involve	ขึ้นอยู่กับ
141.	iodide ion	ไอโอไดต์ ไอออน
142.	isolated	โดดเดี่ยว
143.	isotropic	ซึ่งมีคุณสมบัติทางกายภาพเท่ากันหมดทุกทิศทาง
144.	layer	ชั้น

145.	lead to	นำไปสู่
146.	learned	ที่เรียนรู้
147.	level	ระดับ
148.	limit	ขอบเขต
149.	magnetic field	สนามแม่เหล็ก
150.	maintain	รักษาไว้
151.	major	สำคัญ
152.	mass	มวล
153.	mass transport	การเคลื่อนที่ของมวล
154.	material	สาร
155.	mechanical stress	แรงกล
156.	mechanism	กลไก
157.	medium	สาร
158.	membered	จำนวน
159.	methanol	เมทานอล
160.	methyl t-butyl ether	เมทิล เทอเทอิล บิวทิล อีเทอร์
161.	migration	การอพยพ
162.	minus	เครื่องหมายลบ
163.	molecular formula	สูตรโมเลกุล
164.	motion	การเคลื่อนที่
165.	multicellular	ที่มีเซลล์หลายตัว
166.	mutation	การเปลี่ยนแปลง
167.	navigational	นำทาง
168.	necessarily	จำเป็น
169.	negative	ลบ
170.	net flow	ผลรวมจากการไหล
171.	node	บัพ
172.	note	บันทึก
173.	normally	โดยปกติ
174.	nucleophile	นิวคลีโอไฟล์

175.	nucleophilic attack	การเข้าไปทำของนิวคลีโอไฟล์
176.	nucleophilicity	นิวคลีโอฟิลลิตี
177.	numerous	มากมาย
178.	observation	การสังเกตการณ์
179.	occupy	ครอบครอง
180.	occur	เกิดขึ้น
181.	odor	กลิ่น
182.	optimally	เหมาะสมที่สุด
183.	orbital	วงจรรอบ ๆ นิวเคลียสของอะตอม
184.	ordinary	ธรรมดา
185.	organism	สิ่งมีชีวิต
186.	oscillation	การแกว่ง
187.	outer	ส่วนนอก
188.	ovary	รังไข่
189.	overall	ทั้งหมด
190.	parallel	ขนานกัน
191.	particle	อนุภาค
192.	particular	โดยเฉพาะ
193.	photosynthesis	การสังเคราะห์จากแสง
194.	physical	ทางกายภาพ
195.	planet	ดวงดาว
196.	planetary	ของดาวต่าง ๆ
197.	play a role	มีบทบาท
198.	point	จุด (v); ตำแหน่ง, จุด (n)
199.	polarizability	โพลาไรเซบิลิตี
200.	polarization	โพลาไรเซชัน
201.	position	ตำแหน่ง ที่ตั้ง
202.	potential	ที่มีประสิทธิภาพ
203.	preceding	ข้างคน
204.	pressure	แรงกดดัน

205.	primitive	เก่าแก่
206.	primordial	ลำดับต้น
207.	properly	โดยถูกต้อง พอดี
208.	protective	ป้องกัน
209.	protozoa	โปรโตซัว
210.	provide	ให้
211.	reaction	ปฏิกิริยา
212.	readily	เกิดขึ้นได้เรื่อย ๆ
213.	regularity	ความคงที่
214.	relate to	เกี่ยวข้องกับ
215.	related	ที่เกี่ยวข้อง
216.	relative	เปรียบเทียบ, สัมพันธ์กัน
217.	release	ปล่อย
218.	replacement	การแทนที่
219.	represent	เป็นตัวแทน
220.	require	ต้องการ
221.	resonator	ตัวกำหอน (สิ่งที่ทำให้เกิด resonance)
222.	respond	ตอบสนอง
223.	revolve	หมุนรอบ
224.	rigid	แข็ง
225.	ring	วงแหวน
226.	seasonal	ตามฤดูกาล
227.	secrete	ขับออก
228.	seem	ดูเหมือนว่า
229.	sensitive	ไว
230.	sensory cell	เซลล์รับความรู้สึก
231.	set	ชุด
232.	set free	ปล่อย
233.	share	ใช้ร่วมกัน
234.	sign	เครื่องหมาย

235.	simultaneously	ในเวลาเดียวกัน
236.	solvent	ตัวทำละลาย
237.	source	แหล่งกำเนิด
238.	spatial	เกิดขึ้นในพื้นว่าง
239.	specialized	พิเศษ
240.	spin	สปิน
241.	spoiled	เน่าเสีย
242.	static electric field	สนามไฟฟ้าสถิต
243.	stimuli	สิ่งกระตุ้น
244.	structure	โครงสร้าง
245.	stunt	ฉิ่ง
246.	subject to	ขึ้นอยู่กับ
247.	substance	สาร
248.	suffice	พอเพียง
249.	suggest	บ่งชี้
250.	surface	พื้นผิว
251.	synthesis	การสังเคราะห์
252.	synthesize	สังเคราะห์
253.	system	ระบบ
254.	take place	เกิดขึ้น
255.	t-butyl chloride	เตียเชอริ บัทธิล คลอไรด์
256.	termite	ปลวก
257.	territory	อาณาเขต
258.	transfer	ให้
259.	transform	เปลี่ยน
260.	treat	ถือว่า
261.	upset	ปั่นป่วน
262.	valuable	มีค่า
263.	various	ต่าง ๆ
264.	vary	แตกต่างกันไป

265. violet

สวทไวโอเลต

266. wave

คลื่น

267. wavelength

ความยาวคลื่น

268. wood

ไม้

APPENDIX P

Test of English Grammatical Structures - Test Item Statistics¹

Item	RPB	Diff	Item	RPB	Diff
1	279	605	24	112	305
2	359	652	25	378	600
3	296	584	26	220	273
4	410	636	27	241	294
5	343	657	28	236	484
6	327	368	29	172	284
7	393	442	30	437	657
8	263	194	31	265	394
9	363	594	32	436	636
10	191	615	33	240	552
11	382	715	34	324	657
12	328	642	35	244	447
13	147	452	36	416	531
14	266	689	37	426	705
15	227	278	38	313	542
16	378	421	39	548	642
17	268	294	40	347	578
18	335	315	41	263	442
19	251	557	42	202	221
20	332	647	43	295	600
21	240	378	44	149	421
22	305	442	45	071	157
23	041	247			

¹Decimal points omitted

RPB = point-biserial correlation

Diff = difficulty index

APPENDIX Q

English-Thai Translation Test of English Grammatical Structures -
Administration

ข้อปฏิบัติในการคุมสอบ

English-Thai Translation Test of English Grammatical Structures

1. กรุณาแจกข้อสอบ และ คำศัพท์ ให้หมายเลขตรงกัน
2. ผู้ที่ สมุด คำศัพท์ ให้ น.ศ. เขียน ชื่อ คณะ เพื่อนักศึกษา
ให้วงกลมตัวเลข หน้าคำศัพท์ทุกคำที่กองการคุมความหมาย
3. ผู้ที่ข้อสอบ ให้ น.ศ. เปิดข้อสอบไปไปที่ 3 ซึ่งเป็นหน้าแรกของตัว
ข้อสอบ ให้ เขียน

หมายเลข _____

ชื่อ _____

คณะ _____

4. ชี้แจง

ให้ทำข้อสอบอย่างสุดความสามารถ ข้อสอบชุดนี้วัดความเข้าใจความหมายประโยค
ที่มีโครงสร้างไวยากรณ์ต่างกัน ขอให้ น.ศ. เขียนภาษาไทยให้ชัดเจนอ่านได้ง่าย

ขอเตือน น.ศ. ทุกคนให้เข้าสอบชุดสุดท้าย ในวันจันทร์ที่ 30 ก.ค.

เวลา 1 ชั่วโมง ที่เดิม

ขอให้ น.ศ. ที่เข้าสอบข้อสอบครบทั้ง 4 ชุด รับเงินสมนาคุณหลังจากการสอบ
เสร็จสิ้นแล้ว ในคืนวันที่ 30 ก.ย. ที่อาจารย์คุมสอบด้วย"

5. "ต่อไปนี้ เปิดไปที่ หน้า "คำแนะนำ" อาจารย์คุมสอบอ่าน "คำแนะนำ" ด้วย

6. กรุณาเก็บ ข้อสอบ และ คำศัพท์ แยกออกจากกัน

ขอบคุณ

ศรีปัญญา ใจใหญ่

กรุณาเตือน น.ศ. ว่า ในการแปล ขอให้แปลทุกข้อ ข้อใดคิดว่ายาก ให้เขาเอาอย่าเสียเวลา
กับข้อใดข้อหนึ่งนานเกินไป เพราะมี 45 ข้อ มีเวลาให้ทำ 2 ชม. ครึ่ง
คำใดที่หวั่นไหวได้เพราะเคยใช้ในวิชาวิทยาศาสตร์ ให้ใช้คำศัพท์.

English-Thai Translation Test of English Grammatical Structures -

Administration

1. Distribute both the test booklet and the vocabulary list with the identical test numbers to each student.
2. Ask the students to write their names and their Faculties in the space provided on the vocabulary list. Remind them to circle the number preceding any words which the students need to look up for the meaning.
3. Ask the students to write their names and their Faculties in the space provided on the test booklet.
4. Ask the students to do the test to the best of their ability. Ask them to write clearly sentences in Thai. Remind everybody to attend the final test session on Monday, July 30 at 7.00 p.m. at the same exam room and tell the students that they will receive an envelope of 35 Baht after the final test is completed.
5. Ask the students to turn the test booklet to the instruction page. Read out loud the instructions.
6. Separate the test booklets from the vocabulary lists.

Thank you

Sripanya Chaiyai

P.S. Remind the students to translate every item. Do not spend too much time on each particular item for they have only two hours and a half to translate 45 sentences. English scientific terms which are also of common use in Thai science textbooks can be directly used in the translation of sentences.

APPENDIX R

English-Thai Translation Test of English Grammatical Structures

คำแนะนำ
(Instructions)

ข้อสอบชุดนี้เป็นการทดสอบความเข้าใจความหมายของประโยคที่มีโครงสร้างทางไวยากรณ์ต่างกัน

จงแปลประโยคต่อไปนี้เป็นภาษาไทยให้ได้ใจความครบถ้วน เขียนคำแปลในช่องว่างที่เตรียมไว้ให้ในข้อสอบ

(This test is to see whether you understand English sentences which include different types of grammatical structures.)

Translate the following sentences into Thai as clearly as possible. Write your Thai sentences in the space provided.)

ชื่อ _____
(Name)

.....
(Number)

คณะ _____
(Faculty)

- 1. One can synthesize methyl t-butyl ether from t-butyl chloride by allowing the halide to react with methanol.

(Chem. - p.229)

- 2. Charge is another coefficient, characteristic of each particle, that determines the strength of its electromagnetic interaction with other particles.

(Physics - p.19)

- 3. A protective horny coat of secreted chitin is found on the skin cells of insects and related groups. Numerous other animals secrete horny protein coats on their outer cells:

(Bio. - p.74)

- 4. Biological competition between two different types occupying the same territory often has led to the extinction of one.

(Bio.-p.781)

5. The fact that an electric current produces a magnetic field suggests that a single moving charge must also produce a magnetic field.

(Physics - p.379)

6. Cenozoic climates played a major role in plant evolution, as noted earlier.

(Bio. - p.567)

7. These three features will be seen to be the chief features of the halogenation reaction.

(Chem. - p.32)

8. The magnetic field at points inside a cylinder carrying a current on its surface is zero.

(Physics - p.441)

9. By moving the resonator along the line PQ, Hertz found the position of the nodes and antinodes and the direction of the magnetic field.

(Physics - p.683)

10. In cosmic radiation there are electromagnetic waves of even shorter wavelengths.

(Physics - p.579)

11. We know that men, for example, did not descend "from amoebas" or some other "lower" type.

(Bio. - p.29)

12. Many substances which normally are isotropic become anisotropic when subject to mechanical stresses or to strong static electric or magnetic fields.

(Physics - p.629)

13. Sun compass mechanisms appear to play some role in navigational guidance during seasonal migrations and in homing.

(Bio. - p.438)

14. Because of the negative sign in Equation (16.18), the electric field points in the direction in which the electric potential decreases.

(Physics - p.344)

15. Many of the simpler carboxylic acids occur widely in nature.

(Chem. - p.79)

16. We may assume that the protons are clustered around the center of mass of the atom, forming a sort of nucleus, and the electrons are revolving around it, as in our planetary system.

(Physics - p.393)

17. Each carbon of the C=C is converted to a C=O, and any hydrogen attached to these particular carbons is converted to an -OH group.
(Chem. - p.40)
-
-
-
-

18. An embryonic ovary of a human female is estimated to contain some 400,000 primordial germ cells.
(Bio. - p.502)
-
-
-
-

19. Atmospheric oxygen is the source of the ozone (O_3) layer which envelops the earth at an altitude of some 10 miles.
(Bio. - p.212)
-
-
-
-

20. Most materials in the physical world actually require activation energies far greater than those energies provided by ordinary temperatures.
(Bio.-p.40)
-
-
-
-

21. The fact that the polarizability of the medium is not the same in all directions means that, in general, the polarization \vec{P} does not have the same direction as the electric field \vec{E} .
(Physics - p.626)
-
-
-
-

22. The two spatial arrangements represent two different configurational isomers of the same molecular formula.

(Chem. - p.133)

23. Pressure has far less effect on liquids, which are incompressible and on solids, which may or may not be compressible.

(Bio. - p.40)

24. The minus sign indicates that the net flow (mass transport) is in the direction in which n (the concentration of the substance) decreases.

(Physics - p.284)

25. By absorbing from and adding to the materials in the gut cavity, the large intestine aids in maintaining a properly balanced internal composition of the body.

(Bio. - p.301)

26. In the IUPAC system the hydroxyl group is treated as a functional group, exactly as was the double bond.

(Chem. - p.52)

27. The masses of the fundamental particles do not seem to show any kind of regularity.

(Physics - p.518)

28. The preceding considerations would suffice to provide a complete analysis of planetary motion if we were to assume that the motion of a planet around the sun was not affected by the other planets and heavenly bodies.

(Physics - p.313)

29. According to the hypothesis of "large" mutations, a major mutation is assumed to transform an organism suddenly, in one jump, to a completely new type.

(Bio. - p.544)

30. In the gut of termites live flagellate protozoa which secrete an enzyme capable of digesting the cellulose of wood.

(Bio. - p.105)

31. That the nucleophilicity of Nu^{\ominus} does not necessarily parallel its basicity is evident from the fact that iodide and cyanide ion, which are considerably weaker bases than hydroxide ion, are both stronger nucleophiles.

(Chem. - p.222)

32. Most of the observations made on earth are related to a frame of reference attached to it.

(Physics - p.81)

33. We have already mentioned that indicating the various covalent bonds can be done by using a dash to represent each shared pair of electrons.

(Chem. - p.16)

34. The energy levels of an atom with several electrons are much more complex than those of atoms with one electron.

(Physics - p.602)

35. The intramolecular aldol type of condensation is very valuable as a cyclization reaction leading to the formation of five- and six-membered rings.

(Chem. - p.360)

36. Many multicellular organisms have highly specialized sensory cells that are exceedingly sensitive and respond to even weak stimuli.

(Bio. - p.22)

37. He experiments with some billiard balls by dropping them, and notes that all of them fall with the same acceleration.

(Physics - p.324)

38. A fungus is covered by a rigid wall composed of cellulose in primitive types ...

(Bio. - p.162)

39. IUPAC names of simpler carboxylic acids are still much less frequently used than the common names by which they had been known up to that time.

(Chem. - p.79)

40. The various orbitals in which the electrons of an isolated atom may be found are called atomic orbitals.

(Chem. - p.10)

41. A carbon atom that employs this set of orbitals for bonding is said to have sp^2 hybridization.

(Chem. - p.15)

42. Nowadays chemists wish to devise syntheses of exotic molecules found in nature.

(Chem. - p.462)

43. The fins of a fish and the arms of a man are basically the same kind of structure.

(Bio. - p.27)

44. In general, the different relative strengths by which electrons are attracted to their own nuclei will determine whether two atoms will transfer or share electrons between them.

(Bio. - p.60)

45. There are a number of other reactions of acid derivatives that also involve initial nucleophilic attack on the carbonyl group.

(Chem. - p.405)

APPENDIX S

Key for the English-Thai Translation Test of
English Grammatical Structures

คำเฉลยข้อสอบแปล

1. เราสามารถสังเคราะห์เมทิลเททราไฮโดรพิวทิลฮีโรรี จาก เททราไฮโดรพิวทิลคลอไรด์ได้ โดยให้ เอโลดัล ทำปฏิกิริยากับเมทธานอล
2. ประจุเป็นสัมประสิทธิ์อีกอย่างหนึ่งซึ่งเป็นลักษณะเฉพาะตัว ของอนุภาคแต่ละชนิดซึ่ง กำหนดถึงความแรงของอันตรกิริยาทางแม่เหล็กไฟฟ้าที่มีต่ออนุภาคอื่น ๆ
3. ที่เซลล์ผิวของแมลงและสัตว์ที่สดอยู่ในกลุ่มเดียวกับแมลงจะมีสารแข็งเหนียว ที่ถูกปล่อยออกมาเป็น กระจุกป้องกันอยู่ มีสัตว์จำพวกอื่น ๆ อีกมากที่ปล่อยสารโปรตีนที่แข็งเหนียวออกมาเคลือบผิวนอกของเซลล์
4. การแข่งขันกันทางชีววิทยาระหว่างสิ่งมีชีวิตสองชนิดที่ครอบครองอาณาเขตเดียวกัน ย่อมนำไปสู่การสูญพันธุ์ของฝ่ายใดฝ่ายหนึ่ง
5. ข้อเท็จจริงที่ว่า กระแสไฟฟ้าทำให้เกิดสนามแม่เหล็กนั้นชี้ให้เห็นว่า ประจุเดียวที่เคลื่อนที่ ต้องผลิตสนามแม่เหล็กอันหนึ่งขึ้นด้วย
6. ภูมิภาคาค่าในยุคซีโนโซอิก มีบทบาทที่สำคัญมากอันหนึ่งต่อการวิวัฒนาการของพืช ดังที่ได้กล่าวไว้แล้วข้างต้น
7. จะเห็นได้ว่า คุณสมบัติทั้งสามประการนี้คือคุณลักษณะที่สำคัญของปฏิกิริยา เอโลดัล เชนขึ้น
8. สนามแม่เหล็กที่จุดใด ๆ ภายในกระบอกที่มีกระแสไฟฟ้าไหลอยู่บนผิว จะมีค่าเป็นศูนย์
9. เซลล์ได้พบตำแหน่งของบัพ และปฏิบัพ และทิศทางของสนามแม่เหล็กโดยการเลื่อนตัว ท่อนไปตามเส้น พิคิว (PQ)
10. ในรังสีคอสมิก มีคลื่นแม่เหล็กไฟฟ้าที่มีความยาวคลื่นสั้นกว่าความยาวคลื่นที่สว่างถึงแล้ว เสียอีก
11. เราทราบกันว่า มนุษย์ไม่ได้สืบทอดมาจากสัตว์จำพวกอริบา หรือ สัตว์จำพวกอื่นที่ต่ำกว่า อริบา

12. สารหลายอย่างซึ่งปกติมีคุณสมบัติทางกายภาพเท่ากันหมดในฐกษัคค่าง กลายเป็นสารซึ่งมีคุณสมบัติทางกายภาพต่างกันในแกหคค่างกัน เมื่อยู่ภายใต้แรงกด หรือ ส่นามไฟฟ้าสถิต หรือ ส่นามแม่เหล็กที่มีความเข้มสูง
13. ดูเหมือนว่า กลไกที่อาศัยดวงอาทิตย์เป็นเหมือนเข็มขัดทางจะมีบทบาทอยู่บ้าง ในการนำทางในระหว่างการอพยพประจำฤดู และในการอพยพกลับสู่บ้านเกิด
14. เป็นเพราะเครื่องหมายลบในสมการ (16.18), ส่นามไฟฟ้าซึ่งเข้าไปในทิศทางที่ศักย์ไฟฟ้าลดลง
15. กรตคาร์บอนซิลิค ชนิดง่าย ๆ เป็นจำนวนมาก เกิดขึ้นทั่วไปในธรรมชาติ
16. เราอาจสมมติได้ว่า การที่โปรตอนเกาะกันเป็นกลุ่มอยู่รอบ ๆ จุดศูนย์กลางมวลของอะตอม เกิดเป็นนิวเคลียสแบบหนึ่ง และมีอิเล็กตรอนโคจรอยู่รอบ ๆ นิวเคลียสนั้น เป็นเหมือนกันกับระบบดาวเคราะห์ของเรา
17. คาร์บอนแต่ละตัวของ $C=C$ จะถูกเปลี่ยนไปเป็น $C=O$ และไฮโดรเจนที่เชื่อมติดกับคาร์บอนเหล่านี้ก็จะถูกเปลี่ยนไปเป็นกลุ่ม $-OH$
18. กะประมาณได้ว่า รั้งไข่ของเด็กรอานที่เป็นเพศหญิง จะมีเซลล์พันธุขัณแรกอยู่ประมาณ 400,000 เซลล์
19. ขัณบรรยากาศออกซิเจนเป็นต้นกำเนิดของชั้นโอโซน ซึ่งห่อหุ้มโลกอยู่เหนือพื้นโลกขึ้นไปประมาณ 10 ไมล์
20. ส่นารส่วนใหญ่ที่มีอยู่ในโลกกายภาพจริง ๆ แล้วอาศัยพลังงานกระตุ้นมากกว่าพลังงานที่ได้มาจากอุณหภูมิธรรมดา
21. ข้อเท็จจริงที่ว่าโพลาไรเซชันของส่นารตัวกลางไม่เท่ากัน ในฐกษัคค่างนั้นหมายความว่าโดยทั่วไปแล้วโพลาไรเซชัน ϵ ไม่ได้รัคค่างเดียวกันกับส่นามไฟฟ้า ϵ .
22. การสั่นเรียงตัวที่ เกิดขึ้นในท้ว่าง ล่องแบบ แสดงถึงการเรียงตัวที่ต่างกันของ ไอโซเมอร์ที่มีสูตรโมเลกุลเหมือนกัน
23. แรงกด มีผลน้อยลงเมื่อกระทำต่อของเหลวซึ่งอัดไม่ได้และต่อของแข็งซึ่งอาจจะอัดได้หรืออัดไม่ได้

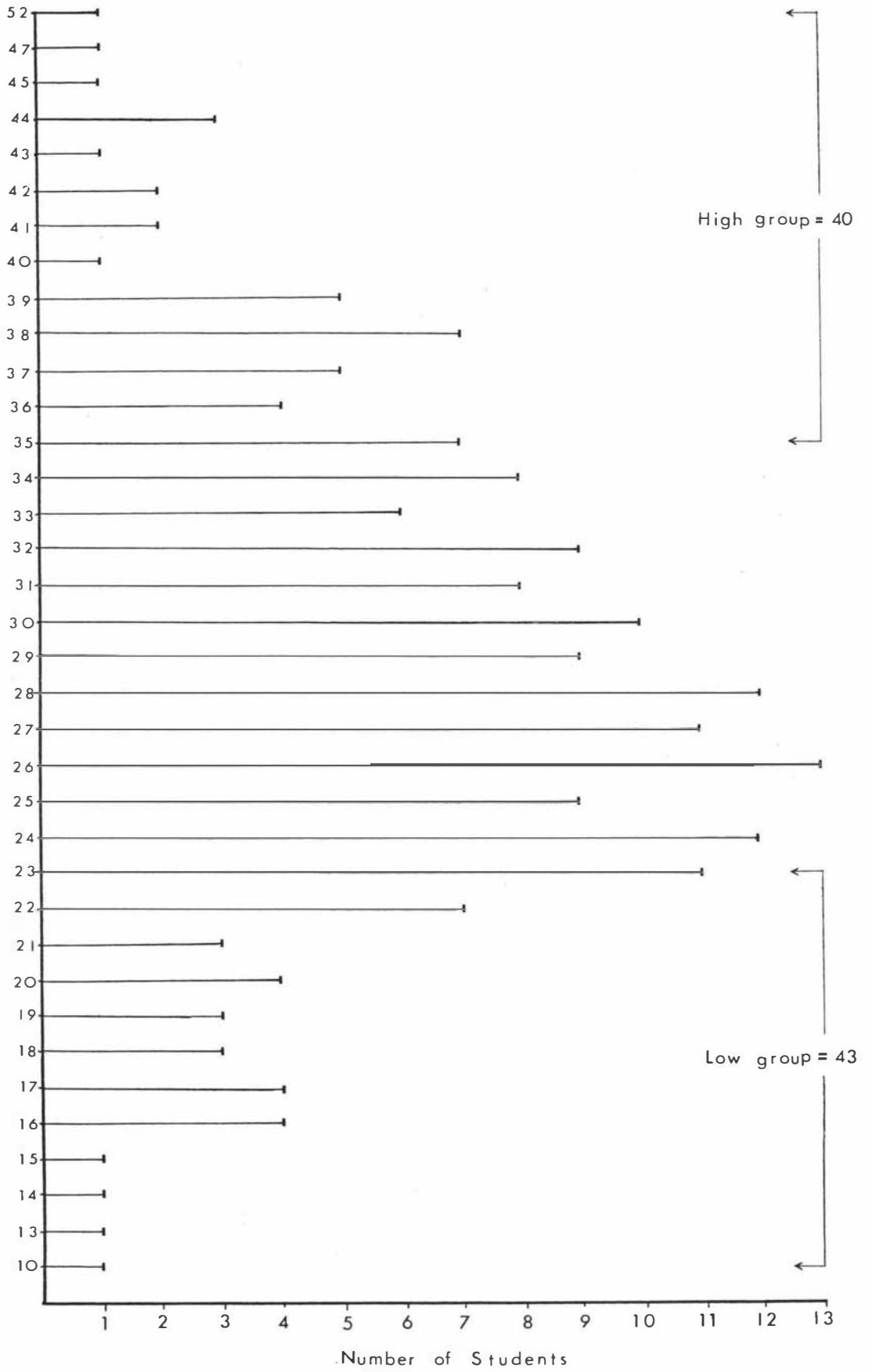
24. เครื่องหมายลบ แสดงให้เห็นว่า อัตราไหลสุทธิเป็นไปในทางที่ n (ความเข้มข้นของสาร) ลดลง
25. ล่าไล้ใหญ่ช่วยรักษาสภาวะสมดุลย์ของส่วนประกอบภายในของร่างกายได้ โดยการดูดซึมออกไปจากสารและเพิ่มเข้าสู่สารที่อยู่ภายในช่องว่างของทางเดินอาหาร
26. ถือกันว่า หมู่ไฮดรอกซิลในระบบ IUPAC เป็นหมู่ที่จะทำปฏิกิริยา เช่นเดียวกับ พันธะคู่
27. ดูเหมือนว่า มวลของอนุภาคมูลฐานไม่ได้แสดงให้เห็นว่ามีความคงที่ใด ๆ เลย
28. ข้อพิจารณาข้างต้นคงจะพอเพียงที่จะทำให้การวิเคราะห์เกี่ยวกับการเคลื่อนที่ของดาวเคราะห์เป็นไปได้อย่างครบถ้วนถ้าเราจะสันนิษฐานว่าการเคลื่อนที่ของดาวดวงใดดวงหนึ่งรอบดวงอาทิตย์ไม่ได้ขึ้นอยู่กับอิทธิพลของดาวดวงอื่น และวัตถุทั้งหลายในจักรวาล
29. ตามข้อสันนิษฐานของการผ่าเหล่าแบบ "ใหญ่" เราสันนิษฐานกันว่า การผ่าเหล่าที่สำคัญคือการเปลี่ยนสิ่งมีชีวิตจากรูปหนึ่งไปเป็นอีกรูปหนึ่ง ในขั้นตอนเดียวอย่างกะทันหัน
30. ใปรोटชีวชนิดมีหมวดซึ่งปล่อยน้ำย่อยที่ช่วยย่อยเซลล์ลูลล์ ของเนื้อไม้ได้นั้น อาศัยอยู่ในระบบทางเดินอาหารของปลวก
31. ข้อที่ว่า นิวคลีโอไทด์ที่ดี ของ $Nu:^\ominus$ ไม่จำเป็นต้องสอดคล้องกับสภาพความเป็นต่างของมันนั้น เห็นได้ชัดจากข้อเท็จจริงที่ว่า ไอโอไดด์ และ ไฮยະไนต์ อีออน ซึ่งถือว่า มีสภาพเป็นต่างอ่อนกว่า ไฮดร็อกไซด์ อีออน ต่างก็เป็น นิวคลีโอไฟล์ที่แรงกว่า ไฮดร็อกไซด์ อีออน
32. การสังเกตการณ์ส่วนใหญ่ที่ทำกันบนพื้นโลก เกี่ยวพันกับกรอบอ้างอิงซึ่งติดอยู่กับโลก
33. เราเคยอ้างมาแล้วว่า การแสดงให้เห็นถึงพันธะโควาเลนต์ ต่าง ๆ นั้นกระทำได้โดยการใส่เครื่องหมายขีดแทน อิเล็กตรอนที่ใช้ร่วมกันแต่ละคู่
34. ระดับพลังงานของอะตอมที่มี อิเล็กตรอน หลายตัว มีความซับซ้อนมากกว่าระดับพลังงานของบรรดาอะตอมที่มีอิเล็กตรอนตัวเดียว
35. การเกิดปฏิกิริยาการควบแน่นชนิด แอลดอล ภายในโมเลกุลเดียวกันมีคุณค่ามากเพราะเป็นปฏิกิริยาการเกิดโครงสร้างรูปวงแหวน ซึ่งนำไปสู่การเกิดสารประกอบวงแหวนที่มีห้าและหกเหลี่ยม

36. สิ่งมีชีวิตชนิดที่มีหลายเซลล์ เป็นจำนวนมาก มีเซลล์สืบพันธุ์ คู่ซึ่ง ไข่มากและตอบโต้สิ่ง กระตุ้นที่แม้ว่าจะเป็นสิ่งกระตุ้นที่เบาบาง
37. เขาทดลองด้วยการทิ้ง ลูกบอลเสียดีให้ตกลงบนพื้น และบันทึกว่าลูกบอลล้ทุกลูกตกลงบนพื้นใน อัตราเร่งที่เท่ากัน
38. เห็ดรา ถูกห่อหุ้มด้วยผนังแข็งซึ่งประกอบขึ้นมาจาก เซลลูโลสชนิดดึกดำบรรพ์
39. ชื่อของกรดคาร์บอกซิลชนิดง่าย ๆ ที่เรียกกันตามแบบ IUPAC มีใช้กันน้อยกว่าชื่อที่เรียก กันตามแบบสามัญ ซึ่งรู้จักกันมาก่อนสมัยเรารู้ใช้แบบ IUPAC
40. วงจรต่าง ๆ ที่มี อิเล็กตรอนของอะตอมเดี่ยว ๆ อยู่ นั้น เรียกกันว่า วงจรอะตอม (atomic orbitals)
41. คาร์บอนอะตอมซึ่งใช้วงจรชุดนี้สร้างพันธะ เรียกกันว่า sp^2 ไฮบริดเซชัน
42. บัจจุบันนี้ นักเคมีต้องการที่จะคิดค้นหาวิธีการสังเคราะห์ โนมเลกุล แปลก ๆ ที่หาได้ใน ธรรมชาติ
43. กล่าวกันตามพื้นฐานแล้ว ครีปปลาและแขนคนเป็นโครงสร้างแบบเดียวกัน
44. โดยทั่วไปแล้ว แรงสัมพันธ์อันเกิดจากการที่อิเล็กตรอนต่างชนิดในโมเลกุลของพันธะเดี่ยว ที่ต่าง กันนั้น จะเป็นสิ่งบ่งบอกว่า ในระหว่างอะตอมสองตัวนี้จะมีการให้อิเล็กตรอน หรือ จะมีการใช้อิเล็กตรอนร่วมกัน
45. มีปฏิกิริยาอื่น ๆ ของอนุพันธ์กรดอีกหลายปฏิกิริยาที่เกี่ยวข้องกับการเกิดปฏิกิริยาอิมโอฟิลิก ตั้งแต่แรก ที่หมู่ คาร์บอนิล

APPENDIX T

Distribution of Cloze Reading Scores

Cloze Scores



APPENDIX U

Scheffé Multiple Comparisons

Scheffé Multiple Comparisons of Three Types of Complex Structures

Comparison	F	
	Good Readers	Poor Readers
Relatives - Complements	14.38 ^{**}	
Relatives - Comparisons	7.98 [*]	
Complements - Comparisons	0.94 (N.S.)	

** p < .01

* p < .05

Scheffé Multiple Comparisons of the Five English Complements

Comparison	F	
	Good Readers	Poor Readers
Complement 1 - Complement 2	4.81	12.00 [*]
1 - 3	17.76 ^{**}	5.88
1 - 4	1.08	0.16
1 - 5	8.33	0
Complement 2 - Complement 3	4.08	1.08
2 - 4	1.33	9.36
2 - 5	25.81 ^{**}	12.00 [*]
Complement 3 - Complement 4	10.08 [*]	4.08
3 - 5	50.43 ^{**}	5.88
Complement 4 - Complement 5	15.41 ^{**}	0.16

** p < .01

* p < .05

Scheffé Multiple Comparisons of the Five English Comparative Structures

Comparison	F	
	Good Readers	Poor Readers
Comparison 6 - Comparison 7	43.83 ^{**}	5.33
6 - 8	.87	0.08
6 - 9	16.45 ^{**}	4.08
6 - 10	.22	3.00
Comparison 7 - Comparison 8	32.36 ^{**}	6.75
7 - 9	6.58	0.08
7 - 10	37.88 ^{**}	16.30 ^{**}
Comparison 8 - Comparison 9	9.76 [*]	5.30
8 - 10	.22	2.08
Comparison 9 - Comparison 10	12.89 [*]	14.08 ^{**}

** p <.01

* p <.05

Scheffé Multiple Comparisons of the Five English Relative Structures

Comparison	F	
	Good Readers	Poor Readers
Relative 11 - Relative 12	.35	0.18
11 - 13	0	3.89
11 - 14	2.80	5.71
11 - 15	.25	5.71
Relative 12 - Relative 13	3.46	2.41
12 - 14	12.94 [*]	3.89
12 - 15	5.55	3.89
Relative 13 - Relative 14	3.02	0.18
13 - 15	.25	0.18
Relative 14 - Relative 15	1.54	0

* p <.05

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