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MEASURING SYNTACTIC DEVELOPMENT IN L2 WRITING:  
FINE GRAINED INDICES OF SYNTACTIC COMPLEXITY AND  
USAGE-BASED INDICES OF SYNTACTIC SOPHISTICATION

By

KRISTOPHER KYLE

Under the Direction of Scott Crossley (PhD)

ABSTRACT

Syntactic complexity has been an area of significant interest in L2 writing development studies over the past 45 years. Despite the regularity in which syntactic complexity measures have been employed, the construct is still relatively under-developed, and, as a result, the cumulative results of syntactic complexity studies can appear opaque. At least three reasons exist for the current state of affairs, namely the lack of consistency and clarity by which indices of syntactic complexity have been described, the overly broad nature of the indices that have been regularly employed, and the omission of indices that focus on usage-based perspectives. This study seeks to address these three gaps through the development and validation of the Tool for the Automatic Assessment of Syntactic Sophistication and Complexity (TAASSC). TAASSC measures large and fine grained clausal and phrasal indices of syntactic complexity and usage-based frequency/contingency indices of syntactic sophistication. Using TAASSC, this study will address L2 writing development in two main ways: through the examination of syntactic development longitudinally and through the examination of human judgments of writing

proficiency (e.g., expert ratings of TOEFL essays). This study will have important implications for second language acquisition, second language writing, and language assessment.

INDEX WORDS: Second language acquisition, Syntactic complexity, Writing development, Language use, Language assessment, Natural language processing

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by

KRISTOPHER KYLE

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

in the College of Arts and Sciences

Georgia State University

2016

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2016

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May 2016

## **DEDICATION**

This dissertation is dedicated to my wife, Jessica Kyle. Without her unwavering support, this project would have never begun, much less been completed.

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This project represents the culmination of a great deal of time and effort by a great number of people.

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## TABLE OF CONTENTS

<b>ACKNOWLEDGEMENTS .....</b>	<b>v</b>
<b>LIST OF TABLES .....</b>	<b>xi</b>
<b>LIST OF FIGURES .....</b>	<b>xiii</b>
<b>1 INTRODUCTION .....</b>	<b>1</b>
<b>2 SYNTACTIC COMPLEXITY AND SOPHISTICATION.....</b>	<b>8</b>
<b>2.1 Syntactic Complexity .....</b>	<b>8</b>
2.1.1 Commonly used syntactic complexity indices.....	9
2.1.2 Syntactic complexity indices and the Biber Tagger.....	16
2.1.3 Syntactic complexity indices and Coh-Metrix.....	20
2.1.4 Other operationalizations of syntactic complexity.....	25
2.1.5 Longitudinal and cross-sectional research designs .....	26
2.1.6 Summary of syntactic complexity measures.....	27
<b>2.2 Syntactic Sophistication .....</b>	<b>27</b>
2.2.1 Verb-argument constructions.....	29
2.2.2 Psychological reality of VACs in L1 and L2.....	29
2.2.3 VAC development .....	32
<b>2.3 Overview of L2 Syntactic Development Research.....</b>	<b>34</b>
<b>3 TOOL FOR THE AUTOMATIC ANALYSIS OF SYNTACTIC SOPHISTICATION AND COMPLEXITY (TAASSC).....</b>	<b>35</b>
<b>3.1 NLP Processes.....</b>	<b>36</b>
3.1.1 Part of speech tagging.....	36
3.1.2 Constituency parsing.....	39

3.1.3	Dependency parsing.....	42
<b>3.2</b>	<b>Extant automatic indices of syntactic complexity .....</b>	<b>44</b>
3.2.1	Biber Tagger .....	44
3.2.2	Syntactic Complexity Analyzer .....	45
3.2.3	Coh-Metrix.....	46
<b>3.3</b>	<b>Evaluating automatic syntactic complexity analysis tools.....</b>	<b>46</b>
3.3.1	Accuracy .....	46
3.3.2	Range of indices.....	48
3.3.3	Availability .....	48
3.3.4	Portability.....	49
3.3.5	Summary of the characteristics of extant syntactic complexity tools.....	49
<b>3.4</b>	<b>Tool for the Automatic Analysis of Syntactic Sophistication and Complexity.....</b>	<b>50</b>
3.4.1	Syntactic Complexity Analyzer .....	52
3.4.2	Fine-grained clausal complexity .....	54
3.4.3	Fine-grained phrasal complexity.....	56
3.4.4	Syntactic sophistication .....	58
3.4.5	Principal component analysis .....	69
<b>3.5</b>	<b>Conclusion.....</b>	<b>77</b>
<b>4</b>	<b>THE RELATIONSHIP BETWEEN SYNTACTIC COMPLEXITY AND SOPHISTICATION AND L2 WRITING QUALITY.....</b>	<b>78</b>
<b>4.1</b>	<b>Method.....</b>	<b>79</b>
4.1.1	Indices .....	79
4.1.2	Writing proficiency corpus .....	79
4.1.3	Statistical analysis .....	81
<b>4.2</b>	<b>Results and Discussion .....</b>	<b>83</b>

4.2.1	Research Question 1a: Syntactic Complexity Analyzer .....	83
4.2.2	Research Question 2a: Fine-grained clausal complexity .....	86
4.2.3	Research Question 3a: Phrasal complexity .....	89
4.2.4	Research Question 4a: Syntactic sophistication .....	96
4.2.5	Research Question 5a: Combined syntactic complexity and sophistication.....	102
<b>4.3</b>	<b>Summary .....</b>	<b>108</b>
<b>4.4</b>	<b>Limitations and future directions .....</b>	<b>110</b>
<b>4.5</b>	<b>Conclusion .....</b>	<b>111</b>
<b>5</b>	<b>LONGITUDINAL SYNTACTIC DEVELOPMENT .....</b>	<b>112</b>
<b>5.1</b>	<b>Method.....</b>	<b>113</b>
5.1.1	Indices .....	113
5.1.2	Learner corpora.....	113
5.1.3	Statistical analyses .....	118
<b>5.2</b>	<b>Results and Discussion .....</b>	<b>119</b>
5.2.1	Research Question 1b results: Syntactic Complexity Analyzer.....	119
5.2.2	Research Question 1b discussion: Syntactic Complexity Analyzer .....	122
5.2.3	Research Questions 2b-5b results: Other TAASSC index types .....	129
5.2.4	Research Questions 2b-5b discussion: Other TAASSC index types .....	133
<b>5.3</b>	<b>Summary of findings .....</b>	<b>149</b>
5.3.1	Research Question 1b: Syntactic Complexity Analyzer indices.....	149
5.3.2	Research Question 2b: Fine-grained clausal complexity .....	150
5.3.3	Research Question 3b: Fine-grained phrasal complexity .....	151
5.3.4	Research Question 4b: Syntactic sophistication .....	151
5.3.5	Research Question 5b: All TAASSC indices.....	152
5.3.6	Limitations .....	153

5.3.7	Future directions .....	154
<b>6</b>	<b>Conclusion and Outlook.....</b>	<b>154</b>
<b>6.1</b>	<b>The Tool for the Automatic Analysis of Syntactic Sophistication and Complexity</b>	<b>155</b>
<b>6.2</b>	<b>Summary of Findings.....</b>	<b>157</b>
6.2.1	Research Question 1: Syntactic complexity analyzer indices.....	157
6.2.2	Research Question 2: Fine-grained clausal complexity indices.....	158
6.2.3	Research Question 3: Fine-grained phrasal complexity indices .....	159
6.2.4	Research Question 4: Indices of syntactic sophistication .....	160
6.2.5	Research Question 5: All TAASSC indices.....	162
6.2.6	Summary of findings.....	163
<b>6.3</b>	<b>Contributions .....</b>	<b>164</b>
<b>6.4</b>	<b>Implications.....</b>	<b>165</b>
6.4.1	Second language acquisition.....	165
6.4.2	Writing assessment .....	166
6.4.3	Second language pedagogy.....	166
<b>6.5</b>	<b>Limitations .....</b>	<b>167</b>
<b>6.6</b>	<b>Outlook.....</b>	<b>168</b>
	<b>REFERENCES.....</b>	<b>170</b>
	<b>APPENDICES.....</b>	<b>186</b>
	<b>Appendix A: TOEFL Independent Essay Rubric .....</b>	<b>186</b>

## LIST OF TABLES

Table 2.1 Biber-tagger based indices relevant to syntactic complexity proposed in Biber et al. (2011).....	18
Table 2.2 Coh-Metrix indices of syntactic complexity reported by Crossley and McNamara (2014).....	24
Table 2.3 Coh-Metrix indices reported in Guo et al., 2013 .....	25
Table 3.1 Dependency representation of the sentence “The linguist climbs rocks.”.....	43
Table 3.2 Overview of current automatic analysis of syntactic complexity tools .....	50
Table 3.3 A description of syntactic structures counted by SCA .....	53
Table 3.4 A description of SCA Variables .....	54
Table 3.5 Clausal dependent types analyzed by TAASSC .....	55
Table 3.6 Phrase types and dependent types analyzed by TAASSC .....	57
Table 3.7 An overview of the phrasal indices included in TAASSC .....	58
Table 3.8 Main verb lemma frequencies in the the written section of COCA.....	61
Table 3.9 Verb argument construction frequencies in COCA .....	61
Table 3.10 Most common verb argument construction-main verb lemma combinations in COCA .....	62
Table 3.11 Contingency table used to calculate various indices of association strength .....	64
Table 3.12 Strongly attracted SVO – Verb combinations in academic COCA .....	68
Table 3.13 An overview of the syntactic sophistication indices calculated in TAASSC for each subcorpus .....	69
Table 3.14 Component 1: Noun phrase elaboration .....	72
Table 3.15 Component 2: Verb-VAC frequency.....	73
Table 3.16 Component 3: Nouns as modifiers and modifier variation.....	73
Table 3.17 Component 4: Determiners.....	74
Table 3.18 Component 5: VAC frequency and direct objects.....	74
Table 3.19 Component 6: Association Strength .....	75
Table 3.20 Component 7: Diversity and frequency .....	76
Table 3.21 Component 8: Possessives.....	76
Table 3.22 Component 9: Frequency.....	77
Table 4.1 Writing prompts for independent essays in TOEFL public use dataset .....	80
Table 4.2 Overview of writing proficiency corpus.....	80
Table 4.3 Abbreviated TOEFL rubric for independent writing tasks.....	81
Table 4.4 Correlations between holistic essay score and SCA variables entered into regression model.....	84
Table 4.5 Summary of SCA multiple regression model .....	84
Table 4.6 Examples from TOEFL Essays: Mean length of clause.....	85
Table 4.6 Correlations between holistic essay score and clausal complexity variables entered into regression .....	87
Table 4.7 Summary of clausal complexity multiple regression model.....	87
Table 4.9 Examples of non-finite clauses in high-scoring essays .....	88
Table 4.8 Correlations between holistic essay score and phrasal complexity variables entered into regression .....	90
Table 4.9 Summary of phrasal complexity multiple regression model .....	90

Table 4.10 Correlations between holistic essay score and syntactic sophistication variables entered into regression .....	97
Table 4.11 Summary of syntactic sophistication multiple regression model .....	98
Table 4.14 Examples of weak and strong verb-VAC associations in TOEFL essays .....	99
Table 4.15 Examples of high and low frequency VACs .....	99
Table 4.12 Correlations between holistic essay score and variables entered into regression.....	104
Table 4.13 Summary of multiple regression model.....	105
Table 4.14 An overview of the performance of each model tested .....	106
Table 4.15 A comparison of models using Fisher's r to z transformation.....	106
Table 4.16 A comparison of the exact accuracy of the models using McNemar's test.....	107
Table 4.17 A comparison of the exact/adjacent accuracy of the models using McNemar's test	107
Table 5.1 Overview of Salsbury written corpus data.....	114
Table 5.2 Number of words collected per participant in Salsbury subcorpus .....	116
Table 5.3 Essay topics in the Verspoor longitudinal corpus.....	117
Table 5.4 Overview of Verspoor longitudinal corpus data.....	117
Table 5.5 Salsbury corpus: Mean (standard deviation) for selected SCA indices at each collection point .....	120
Table 5.6 Repeated measure analysis of variance results for SCA variables .....	121
Table 5.7 Verspoor corpus: Mean (standard deviation) for selected SCA indices at each collection point.....	121
Table 5.8 Repeated measure analysis of variance results for SCA variables .....	122
Table 5.9 Examples from the Salsbury corpus: Mean length of T-unit.....	123
Table 5.10 Examples from the Verspoor corpus: Mean length of T-unit.....	124
Table 5.11 Examples from the Salsbury corpus: T-units per sentence.....	127
Table 5.9 Salsbury corpus: Mean (standard deviation) for component scores at each collection point .....	130
Table 5.10 Repeated measure analysis of variance results for TAASSC component indices....	131
Table 5.11 Verspoor corpus: Mean (standard deviation) for component scores at each collection point .....	132
Table 5.12 Repeated measure analysis of variance results for TAASSC component indices....	133
Table 5.16 Examples from Marta, T1 (week 3) and T10 (week 50) .....	136
Table 5.17 Examples from the Salsbury corpus: Verb-VAC combination frequency .....	137
Table 5.18 Examples from the Salsbury corpus: Possessives component.....	145
Table 5.19 Examples of main verb use by Fenna in first and last essay.....	148
Table 5.20 The ten strongest effect sizes across the two longitudinal studies.....	153

## LIST OF FIGURES

Figure 3.1 A visual representation of the parse tree for the sentence The linguist climbs rocks.	40
Figure 3.2 Graphic representation of a dependency parse .....	43
Figure 3.3 The TAASSC GUI .....	51
Figure 4.1 Phrasal complexity: Dependents per nominal .....	92
Figure 4.2 Phrasal complexity: Dependents per object of the preposition .....	92
Figure 4.3 Phrasal complexity: Prepositions per object of the preposition .....	92
Figure 4.4 Phrasal variation: Dependents per nominal subject.....	93
Figure 4.5 Phrasal complexity and variation: Direct objects.....	94
Figure 5.1 Increase in TOEFL scores over time (Salsbury) .....	115
Figure 5.2 Increase in holistic scores over time in Verspoor longitudinal corpus.....	118
Figure 5.3 MLTU (Salsbury) .....	125
Figure 5.4 MLTU (Verspoor) .....	126
Figure 5.5 T-units per sentence (Salsbury) .....	128
Figure 5.6 Trends for indices included in the Verb-VAC frequency component (Salsbury).....	134
Figure 5.7 Trends for indices included in the Verb-VAC frequency component (Verspoor) ...	135
Figure 5.8 Verb-VAC frequency component results (Salsbury) .....	139
Figure 5.9 Verb-VAC frequency component results (Verspoor).....	139
Figure 5.10 Indices included in the diversity and frequency component (Verspoor).....	141
Figure 5.11 Diversity and frequency component results (Verspoor).....	143
Figure 5.12 Trends for indices included in the possessives component (Salsbury) .....	144
Figure 5.13 Possessives component results (Salsbury).....	146
Figure 5.14 Trends for indices included in the frequency component (Verspoor).....	147
Figure 5.15 Frequency component results (Verspoor) .....	149



## 1 INTRODUCTION

A key measure of academic and professional success is writing proficiency (Kellogg & Raulerson, 2007). Writing is a multifaceted endeavor (Condon, 2013), and attaining proficiency is often difficult, both for first language (L1) and second language (L2) writers (McNamara, Crossley, & McCarthy, 2010; National Commission on Writing, 2003). Various aspects of writing proficiency have been explored, ranging from humanistic concerns such as writing processes (Casanave, 1994; Graves, 1975), voice (Hirvela & Belcher, 2001), and rhetorical effectiveness (Ferris, 1994) to linguistic concerns such as the characteristics of the words (Kyle & Crossley, 2015; Laufer & Nation, 1995; Linnarud, 1986; McNamara et al., 2010), phrases (Crossley, Cai, & McNamara, 2012; Kyle & Crossley, 2015), and syntactic units (Guo, Crossley, & McNamara, 2013; Lu, 2011; Ortega, 2003) that comprise a text. One particularly important linguistic construct that has been influential in the study of writing has been complexity (Bulté & Housen, 2012).

Complexity has been an important construct in first language (L1) and second language (L2) development for the past 45 years. Larsen-Freeman (1978), drawing on previous work in L1 development (Hunt, 1965), cited complexity as one of three important constructs of language development (in addition to accuracy and fluency). Complexity has been operationalized at both the lexical and syntactic level (Wolfe-Quintero, Inagaki, & Kim, 1998). At the lexical level, complexity, which is also referred to as *sophistication* (e.g., Laufer & Nation, 1995; Linnarud, 1986), is often measured in relation to reference corpus frequency. Highly frequent lexical items seem to be learned first (Nation, 2001) and are therefore considered less sophisticated, while less frequent words are learned later (if at all), and are therefore considered more sophisticated. Complexity is also an important component of syntax. Syntax refers to the systematic ways in

which discrete units (e.g., words) can be combined to create meaningful utterances (e.g., sentences; (Fromkin, Rodman, & Hyams, 2013). At the syntactic level, complexity has generally been operationalized with regard to clausal subordination and/or sentence length (as a proxy for subordination), though there has also been recent interest in phrasal complexity (Biber, Gray, & Poonpon, 2011). A review of the L2 acquisition literature suggests that as learners develop they produce longer and more varied syntactic structures (Ortega, 2003). Even though syntactic complexity indices are often used to investigate development in L2 writing, a fully agreed upon definition of syntactic complexity has yet to be realized (Bulté & Housen, 2012). There are at least three major issues that still exist with regard to extant indices of syntactic complexity that hinder a fuller understanding of syntactic complexity.

First, Wolfe-Quintero et al. (1998), among others, have noted the lack of consistency by which syntactic complexity measures have been defined. A clear, longstanding example is in the counting of clauses. Some studies, for example, define a clause as having a subject and a finite verb (e.g., Polio, 1997) while others include non-finite clauses (e.g., Bardovi-Harlig & Bofman, 1989). Such differences in definitions can make comparisons between studies difficult. To exemplify this issue, the sentence *My goal is to run a marathon* would include one clause in the former definition and two clauses in the latter. Furthermore, some studies do not report how particular structures are defined, making comparisons between studies even more complicated. This issue of consistency and clarity is of course not limited to the finite/non-finite distinction. Because syntax can vary in many ways, even seemingly simple indices such as the number of modifiers per noun phrase (e.g., Crossley & McNamara, 2014) may end up being opaque unless they are exhaustively defined. This issue makes it difficult to compile cumulative, concrete knowledge about the relationship between L2 writing and syntactic complexity.

Second, a number of scholars have noted the issue of granularity (i.e., specificity) of syntactic complexity indices (e.g., Larsen-Freeman, 2009; Norris & Ortega, 2009; Wolfe-Quintero et al., 1998). Despite the fact that there has been relatively consistent positive relationship between measures such as mean length of T-unit (MLTU) and writing development, we know very little about the specific structures that emerge as writing develops because these indices are not sensitive enough to provide this information. Furthermore, these indices also hide the degree to which development in syntactic complexity is linear or not (e.g., Biber et al., 2011; Larsen-Freeman, 2006; Norris & Ortega, 2009; Verspoor, Schmid, & Xu, 2012). For example, while writers tend to write longer clauses as they develop, the specific structures they use to increase clause length may change. Some structures (of various lengths) seem to be prevalent at some stages and less so at others. This issue suggests that using fine-grained indices of syntactic complexity may provide a clearer understanding of how learners develop with regard to syntax. In order to understand the relationship between syntactic complexity and writing development, investigations using more fine-grained indices are likely necessary.

The third issue is that syntactic complexity has largely been interpreted as a *formal* characteristic that is distinct from lexical development. Lexical complexity/sophistication and syntactic complexity indices are often employed in tandem as distinct measures language development (e.g., Guo et al., 2013), but are rarely measured jointly (that is, as a single, interrelated construct; c.f., Crossley, Cai, et al., 2012). Recent investigations from a usage-based perspective, however, suggest that the development of lexis and syntactic forms are likely intertwined (Ellis & Ferreira-Junior, 2009b; Römer, 2009). Furthermore, usage-based perspectives suggest that frequency and contingency (i.e., the probability that a verb and a syntactic construction will co-occur) explain L2 syntactic development in ways that are similar

to lexical development: frequent syntactic constructions (and verb-construction combinations) are learned first and are therefore less sophisticated than less frequent ones. Thus, from a usage-based perspective, the underlying construct that syntactic complexity is assumed to measure (language development at the syntactic level) is best measured by frequency of use and contingency, which may or may not coincide with syntactic measures based on subordination (i.e., t-units). Thus, in this paper, the term *sophistication* will be used to refer to syntactic development from a usage-based perspective and the term *complexity* to refer to the formal characteristic of syntax (e.g., subordination). Syntactic forms that are learned earlier can be considered less sophisticated and/or less complex than forms learned later. *Sophistication* roughly equates to *relative complexity* while *complexity* falls within *absolute complexity* (Bulté & Housen, 2012)

Although usage-based perspectives to language acquisition have gained traction over the past 20 years, most of the extant body of research explores a small number of lexical/syntactic combinations (called *constructions*, e.g., Goldberg, 1995) and has been restricted to relatively early stages of language development. This indicates potential gaps in our understanding of linguistic development for all but the most salient constructions (and only at early stages of development for those construction). Despite concurrent interests in both written language development at the clausal level (e.g., Ortega, 2003) and usage-based language acquisition (e.g., Ellis, 2002a) more research is needed to examine relationships between writing development and clause level construction use in either the L1 or the L2. For instance, a comprehensive frequency database of verb-construction combinations in English (or any other language) would prove beneficial in better understanding syntactic development from a usage-based perspective. This issue has recently begun to be addressed through the use of advanced natural language

processing (NLP) techniques to identify and document the frequency profiles of VACs in the British National Corpus (BNC) (O'Donnell & Ellis, 2010; Römer, O'Donnell, & Ellis, 2015), though there is still work to be done.

This study helps address important gaps in our knowledge of syntactic development in L2 writing by explaining the development and testing of the Tool for the Automatic Analysis of Syntactic Complexity (TAASSC). Using advanced natural language processing technology (e.g., Chen & Manning, 2014), TAASSC reports on a number of fine-grained clausal and phrasal syntactic structures. Additionally, TAASSC reports on the 14 widely used large-grained indices of syntactic complexity implemented in the Syntactic Complexity Analyzer (SCA) (Lu, 2010, 2011). TAASSC also calculates a number of indices of syntactic sophistication, comprised of frequency and contingency-based indices for verb argument constructions derived from the Corpus of Contemporary American English (COCA). By applying the indices measured by TAASSC to longitudinal and cross-sectional corpora of L2 writing, this study examines issues in the measurement of syntactic development from both a syntactic complexity and sophistication perspective. Accordingly, this study is guided by the following research questions:

1. What is the relationship between the Syntactic Complexity Analyzer indices and
  - a. holistic scores of writing proficiency?
  - b. longitudinal writing development?
2. What is the relationship between fine-grained indices of clausal complexity and
  - a. holistic scores of writing proficiency?
  - b. longitudinal writing development?
3. What is the relationship between fine-grained indices of phrasal complexity and
  - a. holistic scores of writing proficiency?

- b. longitudinal writing development?
- 4. What is the relationship between usage-based indices of syntactic sophistication
  - a. holistic scores of writing proficiency?
  - b. longitudinal writing development?
- 5. What is the relationship between all syntactic development indices included in TAASSC and
  - a. holistic scores of writing proficiency?
  - b. longitudinal writing development?

This dissertation is organized as follows: First, the literature, which highlights the rationale for the study, is reviewed. Next, the text analysis tool designed for this project is described. The next two chapters comprise analyses that address the research questions. In the final chapter, the results are summarized and implications are discussed. A more detailed outline of each chapter is provided below.

Chapter 2 comprises a discussion of the literature with regard to syntactic development from two perspectives. The first perspective discussed is that of syntactic complexity, which has dominated second language writing studies for the past 45 years (Larsen-Freeman, 1978; Ortega, 2003, 2015; Wolfe-Quintero et al., 1998). The second perspective discussed is usage-based theories of second language development (Behrens, 2009; Ellis, 2002a; Langacker, 1987; Tomasello, 2003), which posit (among other things) that frequency is the primary component of language development.

Chapter 3 comprises a discussion of the development of TAASSC and the indices it includes. The underlying natural language processing (NLP) techniques used for grammatical and syntactic analysis are first discussed (Brill, 1995; Charniak, 2000; Chen & Manning, 2014;

Klein & Manning, 2003), including part of speech (POS) tagging, constituency parsing, and dependency parsing. A review of extant syntactic development analysis tools then follows, including a comparison of their relative strengths and weaknesses. The attributes of TAASSC and the indices of calculated are then described in detail.

Chapter 4 addresses research questions 1a – 5a by examining the ability of multivariate models comprised of various indices of syntactic development to predict holistic scores of writing quality in TOEFL essays. Following the research questions, longstanding indices of syntactic complexity first investigated, followed by fine-grained indices of clausal complexity, fine-grained indices of phrasal complexity, and VAC-based indices indices of syntactic sophistication. The final analysis of the chapter includes a model that considers all four types of syntactic development indices. The results are then discussed and situated within the literature.

Chapter 5 addresses research questions 1b – 5b by examining the relationship between indices of syntactic development and time spent studying English. Two longitudinal learner corpora are examined that represent two distinct learning contexts and written registers. The first is a corpus of free writes written over the course of one year by students enrolled in an intensive English program (IEP) at a major American university (Salsbury, 2000). The second is a corpus of argumentative essays written by middle-school students at a bilingual school in the Netherlands at six points over a two-year period (Verspoor et al., 2012). Following a number of statistical analyses, the results are then discussed and situated within the literature.

Chapter 6 comprises a summary of the results of the previous chapters. The overall implications of the findings of this dissertation for the study of second language development, second language writing, and second language assessment are also reviewed.

## 2 SYNTACTIC COMPLEXITY AND SOPHISTICATION

In this paper a distinction is made between two operationalizations of syntax, namely *syntactic complexity* and *syntactic sophistication*. Syntactic complexity refers to the formal characteristics of syntax (e.g., the amount of subordination), which has been described as *absolute complexity* (Bulté & Housen, 2012). In contrast, syntactic sophistication refers to the relative difficulty of learning particular syntactic structures (i.e., what Bulté and Housen refer to as *relative complexity*), which (from a usage-based perspective) is related to input frequency and contingency. The term *sophistication* is borrowed from related studies of lexical development (Laufer & Nation, 1995; Linnarud, 1986), which refer to less frequent words as more sophisticated because they tend to be produced by more proficient writers.

This chapter is divided into two sections. The first reviews literature regarding the construct of syntactic complexity and how it has been operationalized in studies of second language writing. The second section reviews literature regarding usage-based perspectives on syntactic development, which provide a theoretical backdrop for operationalizations of syntactic sophistication.

### 2.1 Syntactic Complexity

Syntactic complexity has been operationalized in L2 writing development studies in a variety of ways. This variety, while helpful, has made a general description of L2 writing development in terms of syntactic complexity difficult. In this review, syntactic indices are grouped into four major categories. First, the syntactic indices described by Wolfe-Quintero et al. (1998), many of which have been consistently prevalent in L2 research, are considered. Syntactic complexity indices operationalized by Biber (e.g., Biber, Gray, & Staples, 2014; Biber et al., 2004; Biber, Gray, & Poonpon, 2011), which have had an impact on recent discussions of clausal



and phrasal complexity are then discussed. Next, syntactic complexity indices operationalized using Coh-Metrix, which have been used in a number of recent L2 writing studies (e.g., Crossley & McNamara, 2014; Guo et al., 2013) are considered. Finally, a number of indices not represented in the above categories that have been mentioned in the literature during the past five years (e.g., Bulté & Housen, 2012) are discussed.

### **2.1.1 Commonly used syntactic complexity indices**

A number of indices of syntactic complexity have been proposed and employed in L2 writing studies (Wolfe-Quintero et al., 1998), though only a few have been consistently employed across L2 writing studies (Lu, 2011; Ortega, 2003).<sup>1</sup> This section provides an overview of popular indices of syntactic complexity, with a focus on those reviewed and/or proposed by Wolfe-Quintero et al. (1998).

#### ***2.1.1.1 Mean length of clause***

The mean length of clause (MLC) index is the average number of words per clause. A clause is defined as a subject and a finite verb, though some studies (e.g., Bardovi-Harlig & Bofman, 1989) include clauses with non-finite verbs. MLC can be seen as a global measure of intra-clausal complexity. MLC values can increase due to a myriad of syntactic factors. These include increases in phrasal coordination and modification, aspect use (e.g., simple declarative clauses require no auxiliaries, perfect and progressives require one auxiliary, and perfect/progressive combinations require two) and/or syntax structure (e.g., SV structures require two only words, while SVO structures require at least three) among many others. MLC does not differentiate between clause types (i.e., independent clauses are on an equal footing with

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<sup>1</sup> Wolfe-Quintero et al. (1998) refer to the first three indices reviewed below as indices of fluency. This notion has been contested (Lu, 2011; Norris & Ortega, 2009; Ortega, 2003).

dependent clauses). A number of studies have demonstrated a significant positive relationship between MLC and proficiency levels (e.g., Cumming et al., 2005; Ortega, 2003; Wolfe-Quintero et al., 1998) such that clause length tends to increase as proficiency level goes up, though this is not always the case (Knoch, Rouhshad, & Storch, 2014).

#### ***2.1.1.2 Mean length of T-unit***

The T-unit was proposed by Hunt (1965) as an index of child L1 development and was adopted by SLA researchers beginning in the late 70's (Larsen-Freeman, 1978). A T-unit consists of an independent clause and any dependent clauses attached to it. The sentence *The linguist wears tweed jackets and he enjoys being stylish* includes two independent clauses, and therefore includes two T-units. The sentence *The linguist wears tweed jackets because he enjoys being stylish* includes an independent clause with an attached dependent clause, and therefore includes only one T-unit. Compared to MLC, mean length of T-unit (MLTU) adds an extra level of specificity (i.e., dependent clauses are somewhat disambiguated). A number of studies have demonstrated a positive significant relationship between writing proficiency and MLTU (see Ortega, 2003; Wolfe-Quintero et al., 1998) such that the length of T-units tend to increase as proficiency goes up.

#### ***2.1.1.3 Mean length of sentence***

The mean length of sentence (MLS) index is simply the number of words in a sentence. The definition of a sentence is relatively straightforward and uncontroversial, and is generally referred to as a string of words that starts with a capital letter (excepting proper nouns) and ending with punctuation such as a period, question-mark, and exclamation point. This can be seen as a strong operationalization advantage compared to clausal or T-unit counts because it is less ambiguous and therefore can be counted quickly and reliably. MLS has been shown to be

strongly correlated with MLTU. Lu (2010), for example reported a correlation between MLS and MLTU of  $r = .907$ . A number of studies have demonstrated positive relationships between MLS and language proficiency (see Wolfe-Quintero et al., 1998; Ortega, 2003). One clear issue with MLS as a proxy for MLTU is that there can be multiple T-units per sentence. Furthermore, the existence of run-on sentences will strongly influence MLS counts (one of the main reasons that Hunt, [1965] proposed T-units).

#### ***2.1.1.4 Complex T-units per T-unit***

A complex T-unit is defined as a T-unit that includes both an independent and a dependent clause (Casanave, 1994; Lu, 2011). The ratio of complex T-units per T-unit (CTU/TU) measures the number of T-units that have dependent clauses but is insensitive to the number (above one) or types of extant dependent clauses. Casanave (1994) reported a positive trend between development and CTU/TU, but did not report any statistical findings. Another study that has investigated CTU/TU (Lu, 2011) did not find significant relationships between language development and CTU/TU. Were a positive relationship found between proficiency and CTU/TU, we would be able to suggest that learners use more independent/dependent clause combinations, but would not be able to determine the number or type of dependent clauses.

#### ***2.1.1.5 T-units per sentence***

The number of T-units per sentence (TU/S) essentially measures the amount of (independent) clausal coordination in a text. An index score of 1 would indicate that there is no clausal coordination in an essay, while an index score of 2 would indicate that, on average, every sentence includes one instance of clausal coordination. Of the studies reviewed by Wolfe-Quintero et al., only one of the five studies that employed this index (Monroe, 1975, which investigated French as an L2) reported a significant relationship with language proficiency. This

relationship was negative, suggesting that in the Monroe's study clausal coordination decreased as proficiency increased.

#### ***2.1.1.6 Clauses per sentence***

The number of clauses per sentence (C/S) is a global index that concurrently measures the amount of clausal coordination and subordination in each sentence. The same issues with regard to other sentence-based indices apply (e.g., insensitivity to run-on sentences). Ishikawa (1995) found a positive relationship between C/S and language development over a three-month period, while Lu (2011) found a negative relationship between C/S and school year. This is clearly an area that deserves more attention.

#### ***2.1.1.7 Clauses per T-unit***

The number of clauses per T-unit (C/TU) index measures the amount of clausal subordination in a text, but does not distinguish between types of subordination. Of the eighteen studies reviewed by Wolfe-Quintero et al. (1998) that employed C/TU, six found significant positive relationships between language proficiency and C/TU, one found a significant negative relationship, and 11 did not find a significant relationship. More recently, neither Cumming et al. (2005) in a study of independent TOEFL essays, Knoch et al. (2014) in a longitudinal study, nor Lu (2011) found significant differences between C/TU and development.

#### ***2.1.1.8 Dependent clauses per clause***

The number of dependent clauses per clause (DC/C) index is similar to the (C/TU) index because it also measures the amount of clausal subordination in a text. Lu (2011) found a negative relationship between DC/C and school level (between years 2 and 4), suggesting that writers use fewer dependent clauses as their language proficiency increases.

### ***2.1.1.9 Dependent clauses per T-unit***

The number of dependent clauses per T-unit (DC/TU) index is very similar to the previous two indices (in Lu's [2010] data, DC/C and DC/T were correlated at  $r = .922$ ) that measures the amount of clausal subordination in a text. (Homburg, 1984) found a significant positive relationship between DC/TU and proficiency, Lu (2011) found a negative relationship between the two, and the two studies reported in Vann (1979) failed to find a significant relationship.

### ***2.1.1.10 Coordinate phrases per clause***

The number of coordinate phrases per clause (CP/C) measures the amount of phrasal coordination in a text. Lu (2011) found a positive relationship between CP/C and proficiency levels (years 1-3 and 1-4). This positive relationship suggests that phrasal coordination increases as language learners develop.

### ***2.1.1.11 Coordinate phrases per T-unit***

The number of coordinate phrases per T-unit (CP/TU) is very similar to CP/C (in Lu's [2010] data, CP/TU and CP/C were correlated at  $r = .945$ ). It measures the amount of phrasal coordination in a text (but is not sensitive to the types of phrases in which the coordination takes place). Lu (2011) found a positive relationship between CP/C and language development, but this relationship was only significant between years 1-4.

### ***2.1.1.12 Complex nominals per clause***

Complex nominals include a number of syntactic constructions, including nominal clauses, infinitives or gerunds in the subject position, and nouns in combinations with adjectives, adjective clauses, appositives, prepositional phrases, and/or possessives (Cooper, 1976; Lu,

2011). Lu (2011) found a positive significant relationship between all levels except for between years 3-4 in relation to complex nominals per clause (CN/C).

#### ***2.1.1.13 Complex nominals per T-unit***

The complex nominals per T-unit (CN/TU) index is conceptually similar to CN/C. In Lu's (2011) data, CN/TU and CN/C were strongly correlated ( $r = .867$ ). Wolfe-Quintero et al. (1998) propose that CN/C is a better index than CN/TU because the latter makes a construct-irrelevant distinction (between coordination and subordination). This proposal seems to be borne out in Lu's (2011) data: CN/TU discriminated between the first year and years 2-4, but not for any other adjacent levels while CN/C discriminated between all levels except years 3-4..

#### ***2.1.1.14 Verb phrases per T-unit and verb phrases per clause***

The verb phrases per T-unit (VP/TU) index was proposed by Wolfe-Quintero et al. (1998) and measures the total number of verb phrases in a T-unit, including finite and non-finite verbs. The verb phrases per clause index (VP/C) is the same, but with the clause as the denominator. The only L2 writing study I am aware of that includes VP/TU is Lu (2011), who found no relationship between the index and proficiency.

#### ***2.1.1.15 Passives per T-unit, clause, and sentence***

In Wolfe-Quintero et al.'s (1998) review, only one study (Kameen, 1979) employed passive indices. Kameen (1979) differentiated between active and stative passives, and only included active passives in his counts. Passives per T-unit (P/TU), passives per clause (P/C) and passives per sentence (P/S) all significantly discriminated between “good” and “poor” writers, with “good” writers using more passive constructions than “poor” writers.

### ***2.1.1.16 Other indices proposed by Wolfe-Quintero et al. (1998)***

One particularly important issue addressed by Wolfe-Quintero et al. (1998) is the lack of specificity of the indices described. They therefore proposed a number of more specific indices, which have not yet been employed in L2 writing studies. These cover a number of specific phrasal and clausal categories. For each category, they propose an index with the clause as a denominator and another with the T-unit as the denominator. These categories include the four finite clause types: independent clauses (IndC/C, IndC/TU), adverbial clauses (AdvC/C, AdvC/TU), nominal clauses (NomC/C, NomC/TU), adjective clauses (AdjC/C, AdjC/TU), and the three non-finite verb phrase types: infinitive phrases (InfVP/C, InfVP/TU), gerund phrases (GerVP/C, GerVP/TU), participial verb phrases (PartVP/C, PartVP/C). They also propose two further categories based on definite articles (DefArt/C, DefArt/TU) and indefinite articles (IndefArt/C, IndefArt/TU) on the basis that they are “developmentally important structures” (p. 125).

### ***2.1.1.17 Summary***

This review of indices of syntactic complexity described by Wolfe-Quintero et al. (1998) has demonstrated that large-grained indices, such as MLTU and MLC tend to have a positive relationship with L2 writing development such that syntactic structures tend to get longer and more complex as writers develop (though there are exceptions). It has also indicated that many of these indices are interrelated. Furthermore, many of the large-grained indices do not provide specific information about the syntactic structures that emerge as learners develop. One can relatively confidently say that writers will include more information in each clause or T-unit, but know very little about the types of information/structures included (e.g., adverbials, noun-

phrases, noun-phrase modifiers, etc.) and whether learners at a particular proficiency level are using a consistent set of structures.

### **2.1.2 Syntactic complexity indices and the Biber Tagger**

The Biber Tagger is a text analysis tool that has been predominately used to conduct multidimensional analyses (MDA) of language variation (e.g, Biber, 1988; Biber et al., 2004). The Biber Tagger calculates over a hundred lexical and lexico-grammatical indices. Recent research using the Biber Tagger (Biber et al., 2011) has suggested that traditional clause-based measures of syntactic complexity may not be indicative of academic writing but rather indicative of informal speech. For instance, Biber et al. (2011) compared the frequency of a number of clause and phrase-based features (see Table 2.1 for an overview of these features, and Biber et al., [2004] for a comprehensive description of each) between a corpus of informal spoken conversations and a corpus of academic journal articles. With regard to structural type, they found that the spoken texts contained more finite dependent clauses, while the written academic texts contained more dependent phrases. With regard to syntactic function, they found that spoken texts contained more constituents in clauses while written academic texts contained more constituents in noun phrases. The results of the comparative corpus analysis suggest that traditional clause-based indices may not be not appropriate for L2 developmental writing studies because clausal complexity is a feature of informal spoken texts and not of academic written texts. Biber et al., further propose a number of developmental stages wherein the characteristics of learner language move from informal spoken language to academic written language.

Yang (2013), however, notes that the L1 reference corpus used in Biber et al. (2011) cannot clearly answer questions regarding L2 development. To make such claims, one needs to measure the *development* of language learners' speech and writing, either longitudinally or cross-



sectionally. An analysis of this type would allow for stronger claims to be made about L2 development. In their rebuttal, Biber, Gray, & Poonpon (2013) argue that if the goal of language learners is to become members of the English academic community, they will need to develop language skills that are congruent with that community. Thus, students of English for academic purposes (EAP) should focus more on complex noun phrases and less on clausal subordination as evidenced in L1 writing samples.

Yang's (2013) concerns notwithstanding, Biber et al. (2011) propose a number of indices that are likely important indicators of L2 academic writing development (Biber et al., 2013). The work of Biber et al. and others (Norris & Ortega, 2009) have prompted a new wave of studies comparing clausal and phrase-based features. A few of these studies have used indices based on the Biber Tagger, which are reviewed below, while others (e.g., Crossley & McNamara, 2014) have used alternative noun phrase complexity indices, which are reviewed in a later section.

Table 2.1 Biber-tagger based indices relevant to syntactic complexity proposed in Biber et al. (2011)

Category	Index
Finite adverbial clauses	Total finite adverbial clauses <i>Because</i> clause <i>If</i> clause <i>Although</i> clause
Finite Complement Clauses	verb + <i>that</i> clause verb + <i>WH</i> clause adjective + <i>that</i> clause noun + <i>that</i> clause
Finite noun modifier clauses	<i>that</i> relative clauses <i>WH</i> relative clauses
Nonfinite adverbial clauses	<i>to</i> adverbial clause
Nonfinite complement clauses	verb + <i>-ing</i> clause verb + <i>to</i> clause adjective + <i>-ing</i> clause adjective + <i>to</i> clause noun + <i>of</i> + <i>-ing</i> clause noun + <i>to</i> clause
Nonfinite noun modifier clauses	nonfinite relative clause
Adverbials	adverbs as adverbials prepositional phrases as adverbials
Noun modifiers	attributive adjectives nouns as nominal premodifiers total prepositional phrases as nominal modifiers <i>of</i> as postmodifier <i>in</i> as postmodifier <i>on</i> as postmodifier <i>with</i> as postmodifier <i>for</i> as postmodifier

Note. Adapted from Biber et al. (2011)

Taguchi, Crawford, & Wetzel (2013) investigated differences in L2 writing using six clause-level complexity measures (subordinating conjunctions, verb complements, noun

complements, adjective complements, *that*-relative clauses, and *WH*-relative clauses) and nine phrase-level complexity measures (a number of qualifiers, quantifiers, determiners, articles, conjunctions, adjectives and prepositional phrases). Using these clausal and phrasal complexity measures, they compared a high group and a low group of L2 writers (based on holistic scores). It is difficult to objectively interpret the results of this study because inferential statistics were not used. Nonetheless, (Taguchi et al., 2013) report that the high and low groups demonstrated similar clausal complexity (though subordinating conjunctions and *that*- relative clauses used more often by the low group and *that*- clause verb complements were used more by the high group). With regard to the phrasal complexity features, two differences were reported: attributive adjectives and post-noun-modifying prepositional phrases were used more by the high group. To reiterate, although differences were reported at both clausal and phrasal level, no inferential statistic use was reported, limiting the conclusions noted by the authors.

Biber et al. (2014) conducted an analysis similar to the one conducted in Biber et al. (2011), but instead of analyzing L1 reference corpora, they analyzed responses to the speaking and writing performance tasks that are part of the Test of English as a Foreign Language (TOEFL). They divided the texts in to four categories: independent and integrated speaking and independent and integrated writing. Generally, they found that similar differences existed between L2 texts as were found in the L1 texts used in Biber et al. (2011). For instance, writing samples were reported to have more complexity at the phrasal level (particularly with regard to noun phrases), while spoken texts include more finite clauses and *verb + to* constructions. With regard to development, a full factorial analysis indicated that only two indices significantly interacted with holistic score: high scoring written integrated texts included more attributive adjectives and *verb + that* clause constructions. Further analysis indicated that a combined

spoken/written features index (derived from a multi-dimensional analysis) indicated small, positive relationships between the spoken tasks and the integrated written task and holistic scores. A medium, positive relationship was observed between the combined index and independent written responses. Overall, this study supports the claims made in Biber et al. (2011), but does not provide strong evidence that phrasal features are indicators of writing development.

Parkinson & Musgrave (2014) examined the writing of 21 “upper intermediate” international English for academic purposes (EAP) students and 16 MA TESOL international students. Following Biber et al.'s (2011) position that complex noun phrases are the hallmark of academic writing, they examined the differences in the use of 20 noun modifier types between the EAP and MA TESOL students that fell along Biber et al.'s proposed cline of writing development. Based on their analysis, they concluded that the EAP students showed characteristics of lower levels of development (i.e., reliance on attributive adjectives), while the MA students demonstrated the characteristics of higher levels of development (e.g., phrasal modifiers). These results seem to contradict the findings of Biber et al. (2014), who found that attributive adjectives were indicative of highly scored integrated essays. Some important limitations of the study are that neither writing prompt nor genre was controlled for nor was proficiency controlled, making the results difficult to interpret.

### **2.1.3 Syntactic complexity indices and Coh-Metrix**

Another tool that measures syntactic complexity is Coh-Metrix (Graesser, McNamara, Louwse, & Cai, 2004; McNamara, Graesser, McCarthy, & Cai, 2014), which is an online text analysis tool originally designed to measure textual cohesion in reading comprehension studies. Its usefulness for analyzing L2 writing development, however, has been demonstrated through a

number of studies (Crossley & McNamara, 2014; Guo et al., 2013). The measures that can be freely accessed at [www.cohmetrix.com](http://www.cohmetrix.com) are discussed first, followed by other indices that have been reported in investigations concerning Coh-Metrix and syntactic complexity.

### ***2.1.3.1 Number words before main verb***

The number of words before the main verb (NW->MV) index is a measure of sentence complexity. The “main verb” is operationalized as the main verb in the first independent clause in a sentence. A sentence with highly a complex subject (due to phrasal coordination, embedding, etc.) and/or subordinated adverbial clauses before the main verb would earn high scores. A sentence with a less complex subject (e.g., lacking embedding) or that lacks an adverbial clause before the main verb would earn lower scores, as would any sentence with the same elements applied to a complement (e.g., the direct object) or with adverbial clauses occurring after the main clause. A number of L1 writing studies (McNamara et al., 2010) have used NW->MV to successfully discriminate between high and low proficiency writers. The index was also used in an L2 writing study (Crossley & McNamara, 2014). In this study, Crossley and McNamara investigated the linguistic features of writing quality and L2 writing development over the course of a semester. They reported a significant growth in NW->MV values between the essays written at the beginning and end of a semester ( $p = .024$ ;  $\eta^2_p = .088$ ) and a small, positive (though not significant) relationship between NW->MV values and analytic scores for language use ( $p = .204$ ,  $r = .120$ ) and combined analytic scores ( $p = .065$ ,  $r = .174$ ). A summary of the indices reported in Crossley & McNamara (2014) can be found in Table 2.2.

### ***2.1.3.2 Modifiers per noun phrase***

The modifiers per noun phrase (M/NP) index is conceptually related to the complex nominals per T-unit (CN/TU) index. In Coh-Metrix, noun phrases are defined as the final NP in a

chain of NPs (or as an NP without any NP children). Any children of that NP are considered modifiers. This operationalization includes determiners, adjectives, and nouns as modifiers, but does not include relative clauses or prepositional phrases as modifiers. Guo et al. (2013) reported a small, positive relationship ( $r = .264$ ) between M/NP and TOEFL integrated essay scores and a moderate, positive relationship ( $r = .377$ ) between M/NP and TOEFL independent essay scores. Crossley & McNamara (2014) also reported a longitudinal increase in M/NP ( $p = .007$ ,  $\eta^2_p = .122$ ), and a positive relationship between M/NP and combined scores ( $p = .023$ ,  $r = .213$ ) but not between M/NP and language use scores.

### ***2.1.3.3 Syntactic structure similarity***

Coh-Metrix calculates two syntactic structure indices, one that measures the average similarity between adjacent sentences, and one that measures the average similarity between all sentences. These are calculated by counting the proportion of intersecting syntactic nodes between sentences. Crossley & McNamara (2014), found that an index of syntactic similarity reported a decrease in values for longitudinal growth ( $p = .011$ ,  $\eta^2_p = .110$ ) and small, negative (though statistically insignificant) relationships between the index and language use score ( $p = .074$ ,  $r = -.169$ ) and combined scores ( $p = .097$ ,  $r = -.157$ ).

### ***2.1.3.4 Phrase incidence indices***

In addition to the indices described above, Coh-Metrix also includes a number of indices that count the presence of particular syntactic structures in a text. These include the normed incidence counts (per 1000 words) for noun phrases (NPI), verb phrases (VPI), adverbial phrases (AdvPI), preposition phrases (PPI), agentless passives (APass), negations (Ni), gerunds (Geri) (in Coh-Metrix, gerunds are loosely defined as *-ing* verbs, which includes participles) and infinitives (Infi). Guo et al. (2013) found a small, positive relationship ( $r = .186$ ) between

independent writing scores and gerunds. Crossley & McNamara (2014) reported that the learners increase in their use of verb phrases over a semester of study, but that the incidence of verb phrases is negatively correlated with holistic essay score. The use of prepositional phrases increased both as a function of time and writing quality.

#### ***2.1.3.5 Other Coh-Metrix indices reported in studies***

A number of Coh-Metrix indices related to syntactic complexity that are not available in the online tool have also been used to investigate syntactic complexity in L1 and L2 writing. Crossley & McNamara (2014), for example, reported a number of additional Coh-Metrix indices of syntactic complexity such as the number of subject relative clauses in a text. In addition to the syntactic indices reported above, Crossley and McNamara found that as students developed, their writing included more features attributed to clausal complexity, but that essay raters tended to award higher scores to essays that included more features of phrasal complexity. These, along with their relationship with longitudinal growth, language use scores, and combined scores are included in Table 2.2.

*Table 2.2 Coh-Matrix indices of syntactic complexity reported by Crossley and McNamara (2014)*

Indices	Longitudinal Direction	Strength of Longitudinal Relationship ( $\eta^2$ p)	Relationship with Language Use Score (r)	Relationship with Combined Score (r)
Incidence of all clauses	-	0.144**	-.0295**	-0.350**
M/NP	+	0.122**	0.211*	0.213*
Syntax Similarity	-	0.110**	-.0169	-0.157
VPI	-	0.103**	-0.229*	-0.237*
NW->MV	+	0.088*	0.120	0.174
not negation	+	0.067*	0.194*	0.263**
PPi	+	0.057	0.179	0.229*
Subject relative clauses	+	0.044	0.084	0.099
-that verb complements	-	0.005	0.249**	0.199*
S-Bars	-	0.003	-0.093	-0.130
Infi	+	0.001	0.234*	0.321*

Note. \*\* indicates  $p < .01$ ; \* indicates  $p < .05$

Guo et al. (2013) also reported a number of additional indices of syntactic complexity, such as the number of past participle verbs (reporting that past participle verbs contributed to predictor models of independent and integrated writing scores). Guo et al. also found that verbs in the third person present form and verbs in the base form contributed to a predictor model of integrated writing. Writers who used more past participle verbs and fewer third person and base form verbs tended to earn higher marks. A number of other syntactic indices investigated by Guo et al., along with their reported relationships with independent and integrated writing scores, are included in Table 2.3.



Table 2.3 Coh-Matrix indices reported in Guo et al., 2013

Index	Relationship with Independent Essay Scores ( <i>r</i> values)	Correlation with Integrated Essay Scores ( <i>r</i> values)	Included in online tool?
<b>Grammatical word information indices:</b>			
Personal pronouns	-.297	-.315	No
Past participle verbs	.464	.437	No
Verbs in base form	-.281	-.403	No
3 <sup>rd</sup> person singular present verbs	not reported	.194	No
verbs not in 3 <sup>rd</sup> person singular present tense	-.441	-.344	No
-ing verbs	not reported	.186	Yes
verbs in past tense	not reported	-.165	Yes
<b>Syntactic structure indices:</b>			
M/NP	.337	.264	Yes
Embedded Clauses	-.339	not reported	No

*Note.* Any indices noted as “not reported” were excluded from the analysis due to multicollinearity or failure to reach statistical significance

#### 2.1.4 Other operationalizations of syntactic complexity

Bulté & Housen (2014) operationalized syntactic complexity at three levels according to recent discourse on syntactic complexity (e.g., Norris & Ortega, 2009): the sentence, the clause, and the phrase. Sentence indices were divided into length, sentence composition, and combining/linking. The length indices were mean length of sentence (MLS) and mean length of T-unit (MLTU). The sentence composition indices comprised ratios of particular sentence types to all sentences and included simple sentence (a sentence with a single independent clause and no dependent clauses) ratio (SSR), compound sentence (a sentence with two or more independent clauses and no dependent clauses) ratio (CdSR), complex sentence (a sentence with a single independent clause and at least one dependent clause) ratio (CxSR), and compound complex sentence (a sentence with at least two independent clauses and one dependent clause) ratio (CdCxSR). The combining/linking indices included the ratio of coordinated clauses to

sentence (CCR) and the ratio of subclauses to sentences (SCR). A single clausal complexity index was employed, mean length of finite clause (MLFC), and a single phrasal complexity index, mean length of noun phrase (MLNP) was used. Bulté and Housen compared a text written by L2 writers at the beginning of the semester and at the end of the semester using these ten indices. Of the ten, only three (SCR, CdCxSR, and CdSR) failed to demonstrated significant ( $p < .05$ ) and meaningful ( $d > .20$ ) differences between writings from the beginning and end of the semester. All significant and meaningful relationships increased, with the exception of SSR, which decreased. That is to say that sentential, clause, and noun phrase length (W/S, W/TU, W/FC, and W/NP) and amount of clausal coordination (CCR and CdSR) increased, while simple sentence use decreased. In contrast to the findings of Crossley & McNamara (2014), these findings aligned closely with analytic ratings of language use and combined ratings: a diverging relationship only existed for a number of sentence ratio types.

### **2.1.5 Longitudinal and cross-sectional research designs**

Longitudinal research designs involve the collection of data from a relatively homogenous group of participants over an extended period of time (e.g., Crossley & McNamara, 2014; Knoch et al., 2014). Longitudinal studies allow one to control for individual variation, but can be difficult to implement due to factors such as attrition (Mackey & Gass, 2005). Cross-sectional research designs, on the other hand, involve the collection of data at a single point in time from participants with a wide range of language proficiency (e.g., Guo et al., 2013; Lu, 2011). While individual variability cannot be accounted for, a large amount of data can be collected in a relatively short period of time, and attrition is not a factor (Mackey & Gass, 2005). Likely due to practical concerns, much of the body of knowledge regarding syntactic development is derived from cross-sectional studies (Biber et al., 2014; Guo et al., 2013; Lu,

2011). Additionally, the longitudinal studies that have been conducted tend to examine development over a relatively short period of time (e.g., a semester; c.f., Knoch et al., 2014). Findings from cross-sectional and longitudinal studies often fail to coincide (e.g., Crossley et al., 2014), suggesting the need for more (and longer) longitudinal syntactic development studies to support (or problematize) cross-sectional studies (Ortega, 2003).

### **2.1.6 Summary of syntactic complexity measures**

Due to the overwhelming number and types of indices reviewed, it is difficult to succinctly summarize the extant body of knowledge regarding syntactic complexity and L2 writing development. However, it appears that L2 writing develops with regard to length of clauses, sentences, and T-units (Lu, 2011; Ortega, 2003). Furthermore, the use of phrasal elaboration seems to be linked to academic writing (Biber et al., 2011, 2014), though the ways in which writers develop over time does not always correlate with the features that are characteristic of academic writing (Crossley & McNamara, 2014). Additionally, although many studies (e.g., Bulté & Housen, 2014) report manually annotating texts for syntactic structures, the use of automatic tools is increasing (Biber et al., 2014; Crossley & McNamara, 2014; Lu, 2011), which allows for larger datasets to be analyzed, and for the analysis to be standardized. Additionally, the majority of syntactic development studies have adopted cross-sectional designs (e.g., Guo et al., 2013; Lu, 2011). Future longitudinal studies may be warranted to support (or problematize) the findings of cross-sectional studies.

## **2.2 Syntactic Sophistication**

The study of language acquisition from a usage-based perspective has gained traction over the past 25 years. Generally speaking, a usage-based perspective to language acquisition posits that language learning is no different from other types of experiential human learning

(Bybee, 2006; Langacker, 1987; Tomasello, 2003) in that repeated experiences hearing/using pieces of language results in language learning. It is through the combination of two human cognitive abilities, namely intention-reading and pattern-finding that children are able to acquire, over time, the language system of the adults they interact with (Tomasello, 2003). From a usage-based perspective, all linguistic forms (e.g., words, phrases, syntactic patterns, etc), which are called *constructions* (Goldberg, 1995), are functional form-meaning pairings. Such perspectives challenge the Chomskian (e.g., Chomsky, 1988) notion that the human propensity for language is innate via Universal Grammar (UG). UG posits that humans are “hard-wired” for grammatical knowledge/use via a genetic adaptation of a grammatical system, and that grammatical structures carry no meaning outside of the items that fill them. From this perspective, language learning involves mapping linguistic input onto the innate grammatical system. Usage based perspectives, on the other hand, argue that learners acquire language skills through interacting with the language.

Starting in the 1990’s, usage-based theories of language acquisition began to be empirically tested in first language (L1) acquisition (e.g., Goldberg, Casenhiser, & Sethuraman, 2004; Lieven, Pine, & Baldwin, 1997; Tomasello & Brooks, 1999). By the early 2000’s, usage-based perspectives began to gain traction in the field of second language (L2) acquisition (Ellis, 2002a, 2002b). The unit of investigation in most of this work has been the verb-argument construction (VAC), which consists of a verb-slot and the arguments it takes. A transitive construction, for example, includes a subject, a main verb, and a direct object, such as in the sentence *Jack*<sub>subject</sub> *kicked*<sub>verb</sub> *a ball*<sub>direct\_object</sub>. Research in both L1 and L2 acquisition from a usage-based perspective has been approached through three general methodologies: analysis of interactional corpora, psycholinguistic experiments, and analysis of large reference corpora.

Interactional corpora have been used to investigate the relationship between linguistic input and production in both L1 and L2 acquisition (Ellis & Ferreira-Junior, 2009a, 2009b; Ninio, 1999). Psycholinguistic experiments have been used in conjunction with large reference corpus studies to explore the psychological reality of constructions in L1 and L2 language users (e.g., Gries & Wulff, 2005) and determine the relationship between L1 intuitions and reference corpus data (Ellis, O'Donnell, & Römer, 2014).

### **2.2.1 Verb-argument constructions**

Usage-based theories of language posit that a form/meaning divide does not exist because grammatical forms carry meaning in the same way that lexical items do (Goldberg, 1995; Langacker, 1987). In the sentence *He wugged her the ball*, for example, we can extrapolate the meaning of the nonsense verb “wugged” because the ditransitive (i.e., subject – verb – indirect object - direct object) form carries the meaning of transferring something from one entity to another. This suggests that not only verbs that fill a particular syntactic form have meaning, but the forms themselves (e.g., the ditransitive) also carry meaning. Goldberg (1995) refers to these form-meaning pairings as *constructions*. Constructions occur at multiple levels of abstraction, ranging from morphology to syntax. Verb-argument constructions (VACs), or constructions that consist of a verb and all arguments it takes, have been of particular interest in most areas of L1 and L2 development research (Goldberg et al., 2004; Ninio, 1999; Römer, Roberson, O'Donnell, & Ellis, 2014)

### **2.2.2 Psychological reality of VACs in L1 and L2**

L1 studies suggest that VACs carry as much (or more) meaning as the lexical verbs that fill them do (Bencini & Goldberg, 2000; Chang, Bock, & Goldberg, 2003; Hare & Goldberg, 1999). Bencini and Goldberg (2000), for example, conducted an experiment to determine the

relative importance of verb meaning and construction meaning. They employed a sorting task in which participants ( $n = 17$ ) were given 16 cards, each of which included a distinct sentence that contained one of 4 verbs in one of 4 constructions. Participants were instructed to sort the cards into four groups based on the overall meanings of the sentence. Seven of the participants sorted the cards solely by construction type, none of the participants sorted the cards solely by verbs, and the participants with mixed sorts were closer to construction sortings than verb sortings. These results suggest that a.) construction form-meaning pairings are a psychological reality and b) construction meanings are more salient than verb meanings. Other studies conducted by Goldberg and her colleagues (e.g., Hare & Goldberg, 1999; Chang, Bock, and Goldberg, 2003) provide additional support for the psychological reality of syntactic-semantic mental representations in L1 speakers.

Gries & Wulff (2005) demonstrate that VACs are also likely a psychological reality for L2 learners. In one experiment, advanced L1 German learners of L2 English completed a sentence completion task that was intended to produce either prepositional dative or ditransitive constructions based on a particular subject/verb combination. The German learners' preferences for prepositional dative/ditransitive given a subject and verb followed similar patterns to native speakers (based on reference corpus analysis). Furthermore, the L1 German learners of L2 English made prepositional dative/ditransitive choices that diverged from similar constructions in German, suggesting that advanced L2 learners develop VAC knowledge that is similar to L1 speakers of a target language. In a second experiment, Gries and Wulff replicated the sorting task in Bencini & Goldberg (2000), which found that when asked to sort sentences based on their overall meaning, participants were more likely to sort sentences based on constructions than verbs. In this second experiment, a distinct group of L1 German learners of L2 English

completed a sentence-sorting task. Learners were asked to sort 16 sentences, each of which included a distinct combination: one of 4 verbs and one of 4 constructions into four groups based on the overall meanings of the sentence. The results indicated that the learners were more likely to sort the cards based on constructions than verbs. The results of these two experiments suggest that L2 language learners, like adult L1 speakers, have mental representations of construction form/meaning pairings and that in advanced L2 learners, these representations are similar to those of a fully developed L1 user.

Römer et al. (2014) explored the VAC knowledge of German and Spanish L1 learners of L2 English through corpus studies of the International Corpus of Learner English (ICLE; Granger, Dagneaux, Meunier, & Paquot, 2009), the Louvain International Database of Spoken English Interlanguage (LINDSEI; Gilquin, De Cock, & Granger, 2010) and gap-filling exercises. More specifically, they explored the verbs produced in a number of Subject – Verb – Prepositional Phrase (SVPP) constructions, with a focus on the verbs produced in these constructions in relation to the particular preposition present (e.g., which verbs are produced in SVPP<sub>across</sub>, SVPP<sub>for</sub>, and SVPP<sub>about</sub> constructions). Although the results differed to some degree across corpora and L1 backgrounds, the study provided additional evidence that L2 learners have mental representations of constructions by demonstrating that learners have strong verb preferences for each construction. In a similar study, Römer, O'Donnell, & Ellis (2015) compared the verbs produced in a variety of SVPP contexts by L1 German learners of L2 English, L1 English speakers (via a gap-filling exercise) and their relative frequencies in the BNC. Although the results varied by construction type, the verbs produced by the L1 and L2 users of English were generally highly correlated both with each other and with corpus frequencies.

Taken together, these studies suggest that VACs are indeed a psychological reality and that they carry at least as much meaning as the lexical items that fill them. This appears to be true both for L1 users and for L2 users.

### **2.2.3 VAC development**

L1 child acquisition studies suggest that VACs (and other constructions) are learned and thus not likely innate (Goldberg et al., 2004; Lieven et al., 1997; Ninio, 1999). Particular prototypical “pathbreaking” verbs are used first in constructions for a period of time before the construction is generalized to other verbs. It is through low-variance, high frequency experiences with constructions that language learners are able to generalize, and therefore overcome the so-called poverty of stimulus. Clearly, frequency of input plays an important role in the production of generalized constructions (Behrens, 2009; Tomasello, 2003), suggesting that high frequency constructions will be more easily learned (and therefore be considered less sophisticated) than low frequency constructions.

Fewer studies have explored L2 development from a usage-based perspective. Ellis & Ferreira-Junior (2009a, 2009b) for example, investigated the production of VL, VOL, and VOO by seven adult L2 learners of English and their L1 interlocutors over 23-32 months of study. The verb occupancy frequency profiles for the adult L2 learners closely resembled those of the L1 interlocutors, with very high correlations reported for each construction. Highly frequent verb-construction combinations in the input tended to be produced by the learners more often than verb-construction combinations that occurred less frequently, suggesting that input frequency plays an important role in how verb-construction combinations are learned. Ellis and Ferreira-Junior also explored whether the strength of association between particular verbs and constructions could predict which combinations would be produced by the language learners.



They used a number of verb-construction contingency features in the L1 input to measure association strength. These features correlated highly with L2 production, including collexeme/collostruction strength, which is an index of the joint probability of a verb/construction combination (Gries, Hampe, & Schönefeld, 2005), suggesting that strength of association is an important indicator of L2 construction learning. The findings support the notion that L1 and L2 language development (at least with regard to verb-construction combinations) are similar (Goldberg et al., 2004) and that both input frequency and strength of association are important predictors of L2 production. More frequent/strongly associated verb-construction combinations seem to be learned first (and would therefore be considered less sophisticated) than less frequent/prototypical verb-construction combinations. In addition, Eskildsen & Cadierno (2007) investigation of the development of negations in early L2 learning and Eskildsen's (2009) investigation of the development of the modal *can* suggest that VAC development in L2 learners generally proceeds from a single, potentially fixed construction to a more schematic one, in a manner similar to early L1 learners (Goldberg et al., 2004; Ninio, 1999).

In summary, the reviewed studies have indicated that VACs are a psycholinguistic reality for both L1 and L2 language users. When learning constructions, L2 adults generally begin by learning low-variance or fixed constructions, which develop into schematic form-meaning pairs and that L2 construction learning is affected by input frequency and contingency, which can help explain the general order in which VACs are learned. What is not currently known is whether these trends are stable with regard to proficiency (e.g., continue into intermediate stages of development) and mode (i.e., written versus spoken), and whether these trends are generalizable to all VACs. In order to begin to address this gap, a number of tasks should be completed. First, a full account of the constructions used in the English language needs to be created. Second,

automated indices need to be created to quantify syntactic development based on frequency and contingency. Finally, these indices should be applied to a number of longitudinal and cross-sectional corpora to determine how language use changes over time with regard to syntax.

### **2.3 Overview of L2 Syntactic Development Research**

The extant research regarding L2 syntactic development suggests that as learners become more proficient writers, they tend to write longer clauses, T-units, and sentences (e.g., Lu, 2011; Ortega, 2003) although these results are generally based on relatively small sample sizes (Lu, 2011 being an exception). Research also suggests that phrasal elaboration, and particularly noun phrase elaboration is a feature of academic writing (Biber et al., 2011). Furthermore, learners tend to produce more noun phrases that include more modifiers as a function of time and writing proficiency scores (Crossley & McNamara, 2014). Usage-based research suggests that L2 syntactic development is related to frequency in input and use such that frequently encountered constructions and verb/construction combinations will be learned before less frequent ones (Ellis & Ferreira-Junior, 2009b). There are, however, gaps in our collective knowledge of syntactic development. First, because large-grained indices of clausal syntactic complexity are frequently used, our knowledge about the processes by which clauses, T-units, and sentences become longer (i.e., the specific features that account for the lengthening of these units) is incomplete. Second, indices of phrasal elaboration have been explored with much less frequency than indices of clausal complexity/elaboration, resulting in a relatively limited body of research from which to make generalizations. Furthermore, the most often employed phrasal indices in developmental studies, which have been complex nominals per clause/T-unit (Lu, 2010, 2011), modifiers per noun phrase, and number of words before the main verb (Crossley & McNamara, 2014; Guo et al., 2013) are relatively large-grained, leaving questions about the types of modifiers learners use

as they develop (c.f., Biber et al., 2011, 2014). Finally, usage-based perspectives to syntactic development have only been explored with regard to a small set of constructions (e.g., SVO, SVL) and usually only in oral registers with relatively low-proficiency learners (c.f., Römer et al., 2015).

### **3 TOOL FOR THE AUTOMATIC ANALYSIS OF SYNTACTIC SOPHISTICATION AND COMPLEXITY (TAASSC)**

Syntactic complexity has been of interest in first language (L1) development since the mid 1960's (Hunt, 1965) and second language (L2) development since the mid 1970's (Larsen-Freeman, 1978) respectively. A refined and fully developed definition of syntactic complexity has yet to be agreed upon, but can be defined generally as the existence of a variety of syntactic structures in a particular language use sample. In L2 writing development, this has traditionally focused on clausal subordination (Ortega, 2003; Wolfe-Quintero et al., 1998), but complexity at the phrase level has also recently gained a great deal of interest (e.g., Biber et al., 2011). The calculation of syntactic complexity measures have traditionally been done manually, perhaps leading to the prevalence of large-grained syntactic measures such as the mean length of sentence (MLS) or T-unit (TU). Manual annotation of learner texts is a resource-heavy procedure and is prone to error (Higgins, Xi, Zechner, & Williamson, 2011; Lu, 2010), leading to calls for the automation of such procedures (Bulté & Housen, 2012). Relatively recent advances in computational linguistics and natural language processing (NLP) (e.g., Chen & Manning, 2014; Klein & Manning, 2003) have made the creation of syntactic analysis tools possible (e.g., Biber et al., 2004; Lu, 2010; McNamara et al., 2014).

In this chapter, the NLP processes that allow for the automatic extraction of syntactic complexity measures are outlined, namely part of speech (POS) tagging, constituency parsing,

dependency parsing, and parse tree analysis programs. Three tools that currently measure syntactic complexity automatically are described and their strengths and weaknesses are reviewed. The rationale for a new tool is then given, followed by a description of the Tool for the Automatic Analysis of Syntactic Sophistication and Complexity (TAASSC).

### 3.1 NLP Processes

To analyze syntactic features related to complexity and sophistication one must identify the parts of speech (POS) of the words in a sentence and the syntactic relationships (i.e., constituency and/or dependency relations) between them. A number of computational advances over the past 50 years, and especially over the past 20 years have made the automatic extraction of such features possible (Brill, 1995; Charniak, 2000; Chen & Manning, 2014; de Marneffe, MacCartney, & Manning, 2006; Klein & Manning, 2003). Such advances have made possible the automatic analysis of syntactic complexity (e.g., dependent clauses per clause and modifiers per noun phrase) and syntactic sophistication (e.g., the identification of verb argument constructions). In this section three major NLP processes related to automatic syntactic analysis will be described, namely POS tagging, constituency parsing, and dependency parsing.

#### 3.1.1 Part of speech tagging

The process of POS tagging involves assigning grammatical part of speech tags (e.g., verb, noun, adjective, etc.) to each word in a text. POS tagging is a preliminary step for more advanced processes needed for syntactic analysis (i.e., constituency and dependency parsing) and provides some of the information needed for fine-grained syntactic analyses (e.g., number of nouns as modifiers per noun phrase). The POS tagged version of the sentence *The linguist climbs rocks* is *The\_DT linguist\_NN climbs\_VBZ rocks\_NNS* (as processed by the Stanford POS

tagger), where *DT* = determiner, *NN* = singular common noun, *VBZ* = third person singular verb, and *NNS* = plural common noun. A number of different tagging schemes can be used such as the 61-feature CLAWS5 tagset (Garside, Leech, & McEnery, 1997) or the 45-feature Penn Treebank tagset (Marcus, Marcinkiewicz, & Santorini, 1993) depending on the preferences of the developers.

State of the art POS tagging can achieve accuracies of up to 97% (Jurafsky & Manning, 2008; Toutanova, Klein, Manning, & Singer, 2003). Such accuracy is achieved using a number of methods. Before the methods in which POS taggers such as the Stanford POS tagger (Toutanova et al., 2003) uses in order to achieve such high accuracy are discussed, it is perhaps useful to discuss why POS tagging (and natural language processing in general) might be considered difficult. One important issue is that of linguistic ambiguity. To automatically assign POS tags to a text we could, for example, create a large dictionary of word-POS tag correspondences and use these to assign tags to the words in a text. This method will work for any word in our dictionary that has only one entry (articles such as *the*, *a*, and *an* are good examples), but is problematic for any words with multiple entries. In our word-POS tag dictionary, for example, the word form “book” minimally has two tags, one for the verb sense of book (e.g., I need to *book* my flight to Denver) and one for the noun sense (e.g., I read a good *book* last night). The second major issue is that of unknown words. We can account for a large proportion of running words in a text using a relatively small number of words (Nation, 2001), but Zipf’s law (Zipf, 1935) suggests that there will be a disproportionately large number of words that occur extremely infrequently. Furthermore, new words (and new uses for old words) are created every day, making the likelihood of a POS tagger encountering a new word quite likely, even if we had an extremely large dictionary. Additionally, POS tagsets such as the Penn

Treebank tagset (Marcus et al., 1993) and the CLAWS5 tagset (Garside et al., 1997) include relatively detailed tags (e.g., there are seven tags for verbs in the Penn Treebank) making the task even more difficult (Jurafsky & Manning, 2008).

To solve these problems, two general sets of solutions have been employed: disambiguation rules and probabilistic disambiguation. A disambiguation rule is a generally simple rule that can be used to determine which tag should be given to a particular instance of a word like *book*, which can be given at least a noun or a verb tag. One such rule might be: *If a word that is ambiguously a noun or a verb comes after a determiner, give it a noun tag.* Of course, for such an approach to gain high accuracy, a large number of rules have to be written. Brill (1995) came up with a now-famous solution to the issue of rule-writing, which is called transformation-based learning (TBL). Taking a corpus of training data where each word includes a POS tag (such as the Penn Treebank), a TBL program will create rules based on contextual data. As the TBL program iterates through a corpus, it will generate a large number of rules. Rules that do a better job of explaining the data are kept, while less useful rules are discarded. TBL-based taggers have achieved very high accuracy (up to 97.2% for known words and 96.2% combined known/unknown words; Brill, 1995).

The second solution to the problems of disambiguation and unknown words is to assign the probability of a word/tag combination given corpus derived information. Perhaps the most prevalent probabilistic method is the Maximum Entropy (MaxEnt) method. MaxEnt is essentially multiple logistic regression, a statistical method that is used to predict the class membership of a particular item based on a number of features (Jurafsky & Manning, 2008). In MaxEnt POS tagging, the class membership being predicted is the tag assigned to a word, and this is done based on multiple corpus-based probabilistic features (e.g., the probability of the word *book*

being a noun and a verb based on corpus frequency, the probability that *book* will be a noun or a verb after a determiner, etc.). Various MaxEnt taggers use different compilations of feature sets (i.e., probabilistic relationships that can be used as predictor variables). The Stanford POS Tagger (StanPOS) (Toutanova et al., 2003) is a good example of a MaxEnt tagger that is currently maintained (i.e., it is updated as new software standards are adopted), widely used, and highly accurate (e.g., 97.24% for known words and 96.86% combined).

### 3.1.2 Constituency parsing

Constituency parsing is essential for automatic syntactic analyses because it allows for the identification of phrasal and clausal boundaries, and also allows for the differentiation between independent and subordinated clauses. The notion of grammatical constituency, or the idea that groups of words can together function as a constituent or grammatical unit has been around for about a hundred years (Wundt, 1900). Constituency explains how strings of words such as *the linguist* and *the fashionable linguist* can occur in similar contexts in a sentence and serve similar purposes (i.e., they are both noun phrases). Chomsky (1965) used the idea of constituency as a basis for developing a model for how syntactic systems work. Chomsky theorized that language systems could be described via a number of phrase-structure rules that account for constituencies. Although many formalisms have been derived from Chomsky's theories, computer scientists tend to use phrase structure rules written in Chomsky Normal Form (CNF), in which each rule includes a single structure on the left (e.g., NP) and either one or two structures on the right (Jurafsky & Manning, 2008). Our first example, *the linguist*, which is a noun phrase (NP), can be accounted for in CNF via the rule  $NP \rightarrow \text{determiner (DT) noun (N)}$ . To account for our second example, *the fashionable linguist*, we will need two rules,  $NP \rightarrow \text{DT NP}$  and  $NP \rightarrow \text{adjective (ADJ) N}$ . It is important to note that these rules do not include lexical items,

and therefore theoretically, any ADJ and any N could be used to create a grammatical NP. This has led to describing such a grammar as a “context-free grammar” (CFG). A CFG presents a promising starting point for computational syntactic analysis because it can theoretically use a finite number of rules to describe an infinite number of lexical combinations (sentences). A syntactic parse, then, is a hierarchical representation of the phrase structure rules that account for a particular sentence, which is often called a parse tree. The parse tree for the sentence *The linguist climbs rocks*, for example is: (S((NP (DT The) (NN linguist)) (VP (VBZ climbs) (NP (NNS rocks))))), which can be alternatively represented as in Figure 3.1.

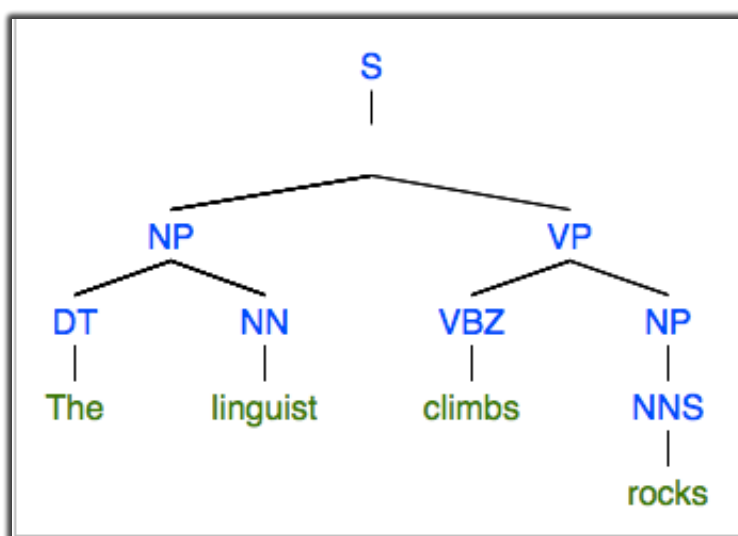


Figure 3.1 A visual representation of the parse tree for the sentence *The linguist climbs rocks*.

Phrase structure rules can of course be handwritten, but they can also be automatically derived from large repositories of hand-annotated sentences such as the Penn Treebank (Marcus et al., 1993). Despite the theoretical advantages of CFGs, there is at least one major drawback: linguistic ambiguity. Syntactic linguistic ambiguity can be demonstrated in many ways and at many levels. One classic type of example, which is outlined in Fromkin et al. (2013), is prepositional phrase (PP) attachment. In the sentence *The boy saw the man with the telescope*, for example, the attachment of the PP *with the telescope* is ambiguous. It is not clear whether the



PP is directly attached to the VP as a sister of *saw* (e.g., VP → V PP) or whether it is directly attached to the NP as a sister of *man* (e.g., NP → N PP): the rules for the grammar allow for both interpretations. While this example is as ambiguous to humans as it is to a computer program, a program based solely on phrase structure rules will have much more difficulty than a human processing the same sentences, especially when we consider that true CFG parsers only use POS tags (not lexical items) as input. One way structural ambiguity can be solved is probabilistically. Given hand-tagged corpora, we can calculate the relative probabilities of each sentence parse based on the POS tags, and assign the most probable parse to a sequence of POS tags (i.e., a POS representation of a sentence). When probabilities are used to disambiguate possible parsers, they are referred to as probabilistic context-free grammar parsers (PCFG parsers).

The accuracy of PCFG parsers has improved through the addition of various degrees of context. Two ways that PCFG parsers have been enhanced is through recognizing grammatical relations and through the use of lexical information (Jurafsky & Manning, 2008). In the Switchboard corpus, for example, the probability of an NP consisting of a pronoun (PRP) (*NP* → *PRP*) and the probability of an NP consisting of a determiner and a noun *NP* → *DT NN* is very similar. If we consider grammatical relations such as subjects and objects of verbs, however, we see that the probability of *NP* → *PRP* is much higher in the subject position than *NP* → *DT NN*, while in the object position, the opposite is true (Francis, Gregory, & Michaelas, 1999). PCFGs can achieve much higher accuracies through the use of such information. Modeling lexical preferences (e.g., n-gram frequencies) can also increase parser accuracy, but can lead to extremely large and therefore slow models. Most current parsers such as the Stanford Parser (Klein & Manning, 2003) tend to use grammatical relations instead of lexical information (Jurafsky & Manning, 2008).

The Charniak parser (Charniak & Johnson, 2005; Charniak, 2000) is another popular parser (in this chapter the configuration outlined in Charniak & Johnson, 2005 is described), but unlike the Stanford Parser, it uses lexical information to obtain an accurate parse. The Charniak parser runs in two stages. First, a text is parsed via a PCFG parser, and the  $n$ -best parses (i.e., the  $n$ -most probable parses) are kept (Charniak & Johnson, 2005 reports on a 50-best parse configuration). Lexical and head information is then added to information available to the probabilistic model, and MaxEnt is used to choose the best parse. Using this method, the Charniak parser can achieve up to 91.0% accuracy, which is state of the art.

### 3.1.3 Dependency parsing

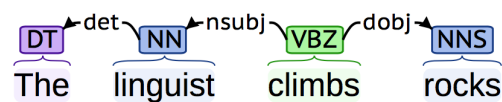
Dependency parsing is useful for automatic syntactic analyses (much like constituency parsing) because it reveals the syntactic relationships between words and phrases in a text. Unlike constituency parsing, which results in a hierarchical representation of phrase structure rules, dependency parsing results in a number of grammatical dependency relations, based on grammatical function (e.g., the subject(s) of a verb). Dependency parsed representations of texts make some syntactic analyses (e.g., identifying arguments of a verbs) much more convenient than constituency parsed representations. Our example sentence, *The linguist climbs rocks*, can be represented as a collection of dependency relations as in Table 3.1, or graphically as in Figure 3.2. Each relation includes a *governor* and a *dependent*. In simple and complex sentences, the main verb of the independent clause is represented as the dependent of the ROOT of the sentence (in graphical representations the ROOT is omitted). Note that single lexical items can be represented both as governors and dependents in different grammatical relations (e.g., the word *linguist* is both a governor of *the* and a dependent of *climbs*). Furthermore, a single word can

have multiple dependents (e.g., the word *climbs* has two dependents: the nominal subject *linguist* and the direct object *rocks*).

*Table 3.1 Dependency representation of the sentence “The linguist climbs rocks.”*

Relation	Governor	Dependent
determiner	<i>linguist</i>	<i>the</i>
nominal subject	<i>climbs</i>	<i>linguist</i>
root	<i>ROOT</i>	<i>climbs</i>
direct object	<i>climbs</i>	<i>rocks</i>

*Note.* This parse was obtained via the Stanford Dependency Parser



*Figure 3.2 Graphic representation of a dependency parse*

Many dependency parsers extract dependency information from constituency parses (i.e., Briscoe, 2006; de Marneffe et al., 2006) via rules, though standalone dependency parsers have existed for some time (e.g., the MALT parser; Nivre, Hall, & Nilsson, 2006). Constituency-based dependency parsers have historically been more accurate than the former (Cer, Marneffe, Jurafsky, Manning, & de Marneffe, 2010), though recent advances have led to superior standalone systems (e.g., Chen & Manning, 2014). The Stanford neural network dependency parser (Chen & Manning, 2014), for example, is capable of state of the art accuracy (around 90%), and is also able to parse texts ten times faster than most constituency parsers (e.g., Klein & Manning, 2003).

Actual dependency representations differ based on the theoretical and practical preferences of the developers. De Marneffe et al. (2006) for example, prefer for heads (governors) to be defined semantically, while others may choose heads (governors) strictly based on form (e.g., Collins, 2003). Dependency representations have been found to be more useful

than constituency representations in a number of NLP processes including information extraction and question answering (e.g., Moldovan, Clark, Harabagiu, & Maiorano, 2003). Recently, dependency representations have been used to automatically identify verb argument constructions (e.g., O'Donnell & Ellis, 2010; Römer et al., 2015). Two particularly popular dependency parsers are the RASP dependency parser (Briscoe, 2006), which tags 17 grammatical relations, and the Stanford Dependency Parser (Chen & Manning, 2014; de Marneffe et al., 2006), which includes 50 grammatical relation tags.

This section has provided an overview of the computer processes involved in automatic syntactic analysis of natural language. Following is a description of three current automated syntactic analysis tools that can be used to measure syntactic development.

### **3.2 Extant automatic indices of syntactic complexity**

A number of text analysis systems currently exist that measure some indices of syntactic complexity. These range from tools built from the ground up to analyze specific linguistic characteristics such as the Biber Tagger, (Biber, 1988; Biber et al., 2004), to tools that utilize pre-existing NLP technology to analyze classic indices of syntactic complexity such as the Syntactic Complexity Analyzer (Lu, 2010, 2011) and innovative indices of syntactic complexity such as Coh-Metrix (Graesser et al., 2004; McNamara et al., 2014).

#### **3.2.1 Biber Tagger**

The original Biber Tagger was introduced in Biber (1988). This version tagged texts for 67 different linguistic features. Although not originally designed to measure syntactic complexity, the depth and breadth of linguistic indices included makes it potentially appropriate for such, as demonstrated by Biber et al. (2014). The Biber Tagger assigns tags in two stages (Biber, 1988). The first stage involves dictionary-based tagging with hand-written

disambiguation rules. The second stage involves identifying particular structures of varying complexity (e.g., *that-verb complements* and *that-adjective clauses*) based on the tags identified in the first stage. A more recent version of the tagger includes tags for 131 linguistic features (Biber et al., 2004), including a number of semantic features. A literature review did not uncover a precise accuracy figure for the performance of the Biber Tagger, although Biber et al. (1988) estimates it to be above 90%. The lack of reporting of performance accuracy is perhaps due to Biber's practice of hand-checking and correcting problematic tags, as described in a number of his publications (e.g., Biber, 1988; Biber et al., 2004). See Chapter 2 for an in-depth discussion of the relationship between syntactic indices measured by the Biber Tagger and L2 writing.

### 3.2.2 Syntactic Complexity Analyzer

(Lu, 2010, 2011) created the Syntactic Complexity Analyzer (SCA) in order to automatically calculate 14 indices outlined in Wolfe-Quintero et al.'s (1998) review of syntactic complexity indices employed in second language (L2) development studies. SCA uses the Stanford Parser (Klein & Manning, 2003) to generate parse trees from target texts. It then uses a number of Tregex (Levy & Andrew, 2006) pattern searches to count instances of eight structures (e.g., clauses, dependent clauses, verb phrases, etc.). These counts, along with text word counts, are then used to produce the 14 indices of syntactic complexity that SCA calculates (e.g., MLC, MLTU). Due to the accuracy of the parser, the adequacy of Lu's pattern matches, and the large-grained patterns the SCA calculates, Lu (2010, 2011) reports high correlations between human and SCA counts for all indices (ranging from  $r = .840$  for dependent clauses per clause, to as high as  $r = .976$  for MLTU). See Chapter 2 for an in-depth discussion of the relationship between syntactic indices measured by SCA and L2 writing.

### **3.2.3 Coh-Metrix**

Coh-Metrix (Graesser et al., 2004; McNamara et al., 2014) is a text analysis tool designed to measure cohesion. The online version of the tool includes 108 indices related to text difficulty, cohesion, psycholinguistic word information, and syntactic complexity. Included are ten indices related to syntactic complexity including the number of words before the main verb, the number of modifiers per noun phrase, and incidence counts of eight particular syntactic features (e.g., noun phrases and gerunds). Syntactic indices in Coh-Metrix are derived from tag information and parse trees generated by the Charniak parser (Charniak & Johnson, 2005; Charniak, 2000). Coh-Metrix syntactic indices have been used to model L2 writing quality (e.g., Guo et al., 2013) and longitudinal L2 growth (e.g., Crossley & McNamara, 2014). See Chapter 2 for a discussion of the relationship between syntactic indices measured by Coh-Metrix and L2 writing.

## **3.3 Evaluating automatic syntactic complexity analysis tools**

Evaluating automatic syntactic complexity analysis tools is not a simple endeavor; there are a number of important characteristics that should be considered. This section discusses the relative merits of three currently available tools on the basis of accuracy, range of indices, availability, and portability.

### **3.3.1 Accuracy**

Of particular import in any automatic linguistic analysis is the issue of accuracy. If one is primarily concerned with counts of particular POS tags in well-edited texts such as newspaper or magazine articles, we can assume that our counts will be very accurate (e.g., 96% or higher; Brill, 1995; Toutanova et al., 2003). If our primary concern is constituency parses of similar texts, we can assume that accuracy will be lower but still relatively high with similar texts (e.g., 91.0%; Charniak & Johnson, 2005). More recent studies have demonstrated comparable

accuracies for some dependency parsers (e.g., between 85-89%; Cer et al., 2010; Chen & Manning, 2014). While the parser accuracies cited thus far are helpful for providing general comparisons between particular POS taggers and parsers, two caveats should be noted regarding the usefulness of accuracy figures.

The first caveat is that syntactic complexity measures are not generally computed on well-edited magazine and newspaper articles (though Biber's work is an exception). Syntactic complexity measures are generally calculated for largely unedited L1 and L2 developmental texts (e.g., timed student essays), which may include features that are relatively infrequent in well-edited, published texts. There is some evidence, however, that parsers work reasonably well with student texts. Hempelmann, Rus, Graesser, & Mcnamara (2006), for example, compared the performance (and speed) of four freely available constituency parsers on a selection of sentences from the Penn Treebank (Marcus et al., 1993) and three L1 student texts (two from college and one from the fifth grade). In this analysis, the Charniak (2000) parser was the most accurate (88.69% average accuracy), followed by the Stanford Parser (83.42%) on the three student texts.

The second issue with published accuracy figures of POS taggers and syntactic parsers is that, depending on the granularity of the syntactic complexity index, absolute parser accuracy may not be particularly relevant. Most syntactic complexity indices are calculated using only a few pieces of a parse. In the identification of verb phrases described earlier, for example, we only need accurate identification of the main VP(s) in a sentence. As with parser accuracy for student texts, very little has been published regarding the accuracy of particular measures of syntactic complexity. The one study that provides systematic accuracy figures for indices of syntactic complexity is (Lu, 2010). Lu reports correlations for the identification each structure of interest in SCA between two human annotators and between the human annotators and SCA.

Despite using L2 texts and the Stanford Parser (which has been shown to be less accurate than the Charniak parser), Lu's SCA achieved very high accuracy scores, ranging from .830 for complex nominals to .976 for T-units (sentences were identified with perfect accuracy). Such performance information has not been made available for the Biber tagger (for reasons already discussed) or for the specific syntactic complexity measures reported by Coh-Metrix, but we can expect that these tools are accurate in light of Lu's (2010) findings.

### **3.3.2 Range of indices**

In order to systematically evaluate language development with regard to syntactic complexity, it is important for an automatic tool to include a broad range of syntactic complexity indices. These indices should include both clausal and phrasal attributes, as noted in the literature (e.g., Biber et al., 2011; Ortega, 2003). Furthermore, syntactic complexity measures should be as fine-grained as possible to allow for a systematic analysis of *all* syntactic changes that are evident both longitudinally and cross-sectionally. The Biber Tagger comes the closest to meeting this criterion because it includes a number of fine-grained indices. SCA includes fourteen indices, nine of which provide analysis at the clausal and/or sentence level. The remaining five provide analysis at the phrase level. Coh-Metrix also provides 10 relevant indices of syntactic complexity (some of which are fine-grained), though these also do not represent the full range of syntactic structures.

### **3.3.3 Availability**

In order to allow for replication, an ideal syntactic complexity tool would be widely available. The online version of Coh-Metrix is freely available via [www.cohmetrix.com](http://www.cohmetrix.com). Users need only to register their email address on the site in order to use it. While the online format allows for users to access the tool from virtually any operating system, it is limited with regard to



its functionality. Texts have to be uploaded to the Coh-Metrix website one at a time, practically limiting the number of texts that can be processed. SCA is freely available and works on any system equipped with the Python programming language and Java. Both Python and Java are available on the three most popular operating systems (Mac OSX, Windows, and Linux Ubuntu) allowing for near universal use. SCA also allows for batch processing. However, some knowledge of Python is necessary in order to operate SCA, limiting its appeal. In contrast, the Biber Tagger is not widely available. It was created and has been maintained by Doug Biber for his own research. Biber is willing to process texts for interested parties (Friginal & Weigle, 2014), but one must wait for his research team to do so.

### **3.3.4 Portability**

Portability is related to the issue of availability. This discussion of portability, however, will focus on the potential for a particular tool to be use on a wide variety of computer systems. One of the reasons the Biber tagger has not been widely released is that the programming language it was written in is no longer being developed/supported (Friginal, 2014). The Charniak parser, which Coh-Metrix uses, is restricted to use on a Windows operating system. The Stanford Parser is written in Java, a computer language that is currently used on all major operating systems.

### **3.3.5 Summary of the characteristics of extant syntactic complexity tools**

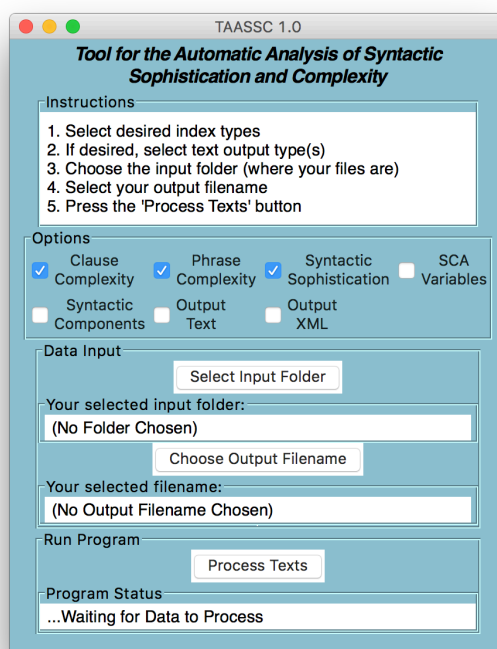
Although three tools exist that automatically measure syntactic complexity, none of them meet all of the criteria for an ideal tool. Table 3.2 summarizes the relative strengths and weaknesses of each tool.

*Table 3.2 Overview of current automatic analysis of syntactic complexity tools*

Tool	Accuracy	Range of indices	Availability	Portability
Biber Tagger	Reported to be high, but exact figures are unknown	Large range of fine-grained indices	Not Widely Available. Researchers can request for texts to be processed.	Not Portable. Currently implemented in an obsolete programming language
Coh-Metrix	Not directly reported, but uses highly accurate parser	Some large and fine-grained indices, but relatively sparse coverage	Available online, but no batch processing.	Not portable as a desktop tool. Uses Charniak Parser.
SCA	Very High	Some fine-grained and large-grained indices. Relatively sparse coverage	Widely available and allows for batch processing.	Very Portable. Utilizes Python and Java

### 3.4 Tool for the Automatic Analysis of Syntactic Sophistication and Complexity

TAASSC was designed to measure a broad range of fine-grained indices of syntactic sophistication and complexity in student writing. It is freely available for research and educational purposes, is accessed through an easy to use graphical user interface (see Figure 3.3), works on Windows, Mac, and Linux operating systems, allows for batch processing, and is stored on the user's hard-drive (allowing one to process sensitive data). TAASSC takes plain text files as input and provides a comma-separated values (.csv) file, which can be opened by any spreadsheet software, as output.



*Figure 3.3 The TAASSC GUI*

TAASSC includes four groups of indices that can be categorized based on the type of parser used in their operationalization. The first group comprises SCA indices. SCA employs the Stanford Parser (Klein & Manning, 2003) and Tregex (Levy & Andrew, 2006) to count structures. The Stanford Parser creates a constituency representation of each sentence in a text, and Tregex is used to find particular patterns in that representation.

The final three groups of indices employ the Stanford Neural Network Dependency Parser (version 3.5.1; Chen & Manning, 2014) and a Python XML parser to count structures. These groups include indices related to fine-grained clausal complexity, fine grained phrasal complexity, and syntactic sophistication, respectively. The Stanford Neural Network Dependency parser combines state of the art accuracy and processing speed. This parser provides a dependency representation of each sentence, which includes a number of functional categories

such as subject and direct object (in addition to a number of other structures). The output of the parser is in XML format, and an XML parser in Python is used to read the file. A description of each group of indices is included below.

### **3.4.1 Syntactic Complexity Analyzer**

Lu's (2010) SCA includes 14 indices of syntactic complexity drawn from Wolfe-Quintero et al. (1998) and Ortega (2003) inter alia. A discussion of each of these indices, including their benefits, drawbacks, and performance is included in Chapter 2. Table 3.3 includes a description of each of the structures counted by SCA, and Table 3.4 comprises a list of the 14 SCA indices including a short description of each. For further information, refer to Chapter 2 and Lu (2010, 2011).

*Table 3.3 A description of syntactic structures counted by SCA*

Structure	Description	Examples
word	a sequence of letters that are bounded by white space	<i>I</i> <i>ate</i>
verb phrase	a finite or non-finite verb phrase that is dominated by a clause marker	<i>ate pizza</i> <i>was hungry</i>
complex nominal	i. nouns with modifiers ii. nominal clauses iii. gerunds and infinitives that function as subjects	i. <i>red car</i> ii. <i>I know that she is hungry</i> iii. <i>Running is invigorating</i>
coordinate phrase	adjective, adverb, noun and verb phrases connected by a coordinating conjunction	<i>She eats pizza and smiles</i>
clause	a syntactic structure with a subject and a finite verb	<i>I ate pizza</i> <i>because I was hungry</i>
dependent clause	a finite clause that is a nominal, adverbial, or adjective clause	<i>I ate pizza because I was hungry</i>
T-unit	an independent clause and any clauses dependent on it	<i>I ate pizza</i> <i>I ate pizza because I was hungry</i>
complex T-unit	a T-unit that includes a dependent clause	<i>I ate pizza because I was hungry</i>
sentence	a group of words bounded by sentence-ending punctuation (., ?, !, ", ...)	<i>I went running today.</i>

Note. Adapted from Lu (2010 pp. 7-13)

*Table 3.4 A description of SCA Variables*

Index Abbreviation	Index Name	Index Description
MLS	mean length of sentence	number of words per sentence
MLT	mean length of T-unit	number of words per T-unit
MLC	mean length of clause	number of words per clause
C/S	clauses per sentence	number of clauses per sentence
VP/T	verb phrases per T-unit	number of verb phrases per sentence
C/T	clauses per T-unit	number of clauses per T-unit
DC/C	dependent clauses per clause	number of dependent clauses per clause
DC/T	dependent clauses per T-unit	number of dependent clauses per T-unit
T/S	T-units per sentence	number of T-units per sentence
CT/T	complex T-unit ratio	number of complex T-units divided by T-units
CP/T	coordinate phrases per T-unit	number of coordinate phrases per T-unit
CP/C	coordinate phrases per clause	number of coordinate phrases per clause
CN/T	complex nominals per T-unit	number of complex nominals per T-unit
CN/C	complex nominals per clause	number of complex nominals per clause

### 3.4.2 Fine-grained clausal complexity

TAASSC includes 31 fine-grained indices of clausal complexity. 29 indices calculate the average number of particular structures per clause. The fine-grained clausal indices included in TAASSC differ from the clausal indices (i.e., MLC, DC/C, CP/C and CN/C) included in SCA in three main ways. First, TAASSC counts the length of clauses as the number of direct dependents per clause instead of the number of words. This prevents structures that inherently include more words (e.g., prepositional phrases) to be given more weight than those that do not (e.g., adjectives). Second, instead of grouping structures (such as dependent clauses or complex nominals) together, TAASSC counts each type separately. Finally, both finite and non-finite clauses are considered clauses by TAASSC.

TAASSC also includes two more general indices of clausal complexity. These indices take into account the total number of dependents per clause. The first index represents the average number of dependents per clause, while the second represents the standard deviation of

the number of dependents per clause, which provides a measure of syntactic variation. Table 3.5 comprises a description of each of the fine-grained indices of clausal complexity in TAASSC.

*Table 3.5 Clausal dependent types analyzed by TAASSC*

Structure	Abbreviation	Example of Structure
adjective complement	acomp	<i>She [looks]<sub>gov</sub> [beautiful]<sub>acomp</sub></i>
adverbial clause	advcl	<i>The accident [happened]<sub>gov</sub> [as night fell]<sub>advcl</sub></i>
adverbial modifier	advmod	<i>[Accordingly]<sub>advmod</sub>, I [ate]<sub>gov</sub> pizza.</i>
auxilliary verb	aux	<i>He[is]<sub>aux</sub> [running]<sub>gov</sub></i>
bare noun phrase temporal modifier	tmod	<i>Last [night]<sub>tmod</sub>, I [swam]<sub>gov</sub> in the pool</i>
clausal complement	ccomp	<i>I am [certain]<sub>gov</sub> [that he did it]<sub>ccomp</sub></i>
clausal coordination	cc	<i>[Jill runs]<sub>gov</sub> and [Jack jumps]<sub>cc</sub></i>
negation	neg	<i>He did [not]<sub>neg</sub> [kill]<sub>gov</sub> them.</i>
clausal prepositional complement	pcomp	<i>They heard [about]<sub>gov</sub> [you missing classes]<sub>pcomp</sub></i>
clausal subject	csubj	<i>[What she said]<sub>csubj</sub> [is]<sub>gov</sub> not true</i>
conjunction	conj	<i>He [runs]<sub>gov</sub> and [jumps]<sub>conj</sub></i>
controlling subject	xsubj	<i>[Tom]<sub>xsubj</sub> likes to [eat]<sub>gov</sub> fish</i>
direct object	dobj	<i>She [gave]<sub>gov</sub> me a [raise]<sub>dobj</sub></i>
discourse marker	discourse	<i>[Well]<sub>discourse</sub>, I [like]<sub>gov</sub> pizza</i>
existential "there"	expl	<i>[There]<sub>expl</sub> [is]<sub>gov</sub> a ghost in the room.</i>
indirect object	iobj	<i>She [gave]<sub>gov</sub> [me]<sub>iobj</sub> a raise</i>
parataxis	parataxis	<i>The guy, John [said]<sub>parataxis</sub>, [left]<sub>gov</sub> early in the morning.</i>
modal auxilliary	modal	<i>He [may]<sub>modal</sub> [be]<sub>gov</sub> awesome.</i>
nominal complement	ncomp	<i>He [is]<sub>gov</sub> a [teacher]<sub>ncomp</sub></i>
nominal subject	nsubj	<i>The [baby]<sub>nsubj</sub> [is]<sub>gov</sub> cute</i>
open clausal complement	xcomp	<i>I am [ready]<sub>gov</sub> [to leave]<sub>xcomp</sub></i>
agent	agent	<i>The man has been [killed]<sub>gov</sub> by the [police]<sub>agent</sub></i>
passive auxilliary verb	auxpass	<i>Kennedy has [been]<sub>auxpass</sub> [killed]<sub>gov</sub></i>
passive clausal subject	csubjpass	<i>[That she lied]<sub>csubjpass</sub> was [suspected]<sub>gov</sub> by everyone</i>
passive nominal subject	nsubjpass	<i>[Dole]<sub>nsubjpass</sub> was defeated<sub>gov</sub> by Clinton</i>
phrasal verb particle	prt	<i>They [shut]<sub>gov</sub> [down]<sub>prt</sub> the station</i>
prepositional modifier	prep_	<i>They [went]<sub>gov</sub> [into the store]<sub>prep</sub> into</i>
subordinating conjunction	mark	<i>Forces engaged in fighting [after]<sub>mark</sub> insurgents [attacked]<sub>gov</sub></i>
undefined dependent	dep	<i>N/A</i>

*Note.* "gov" represents the governor of the dependent; \*prepositional modifier representations include the actual preposition

### **3.4.3 Fine-grained phrasal complexity**

TAASSC includes phrasal indices for seven noun phrase types and ten phrasal dependent types (see Table 3.6 for an overview of these structures). Three types of phrasal indices are included in TAASSC. The first type calculates the average number of dependents per each phrase type (e.g., nominal subjects) and for all phrase types. The second type calculates the occurrence of particular dependent types (e.g., adjective modifiers) regardless of the type of noun-phrase they occur in. The final phrasal index type calculates the average occurrence of particular dependent types in particular types of noun phrases (e.g., adjective modifiers occurring in nominal subjects).



Table 3.6 Phrase types and dependent types analyzed by TAASSC

Structure	Abbreviation	Example of structure
<b>Phrase types</b>		
nominal subject	nsubj	<i>[The man in the red hat]<sub>nsubj</sub> gave the tall man the money.</i>
passive nominal subject	nsubj_pass	<i>[The tall man]<sub>nsubj_pass</sub> was given money by the man in the red hat</i>
agent	agent	<i>The tall man was given money by [the man in the red hat]<sub>agent</sub></i>
nominal complement	ncomp	<i>He is [a tall man]<sub>ncomp</sub></i>
direct object	doobj	<i>The man in the red hat gave the tall man [the money]<sub>doobj</sub>.</i>
indirect object	iobj	<i>The man in the red hat gave [the tall man]<sub>iobj</sub> the money</i>
prepositional object	pobj	<i>The man in [the red hat]<sub>pobj</sub> gave the tall man the money</i>
<b>Dependent types</b>		
determiners	det	<i>[The]<sub>det</sub> man in [the]<sub>det</sub> red hat gave [the]<sub>det</sub> tall man [the]<sub>det</sub> money</i>
adjective modifiers	amod	<i>The man in the [red]<sub>amod</sub> hat gave the [tall]<sub>amod</sub> man the money</i>
prepositional phrases	prep	<i>The man [in the red hat]<sub>prep</sub> gave the tall man the money</i>
possessives	poss	<i>That is [her]<sub>poss</sub> red car</i>
verbal modifiers	vmod	<i>I don't have anything [to say]<sub>vmod</sub> to you</i>
nouns as modifiers	nn	<i>[Oil]<sub>nn</sub> prices are rising</i>
relative clause modifiers	rmod	<i>I saw the man [you love]<sub>rmod</sub></i>
adverbial modifiers	advmod	<i>We will drive the red car [tomorrow]<sub>advmod</sub></i>
conjunction “and”	conj_and	<i>Jack [and]<sub>conj_and</sub> Jill</i>
conjunction “or”	conj_or	<i>Jack [or]<sub>conj_or</sub> Jill</i>

### 3.4.3.1 Treatment of pronouns

Noun phrases in English can consist of pronouns, and except in very rare cases, pronouns do not take direct dependents (relative clauses being an exception). Due to the potential for pronouns as phrases to skew counts of dependents, TAASSC includes two versions of each index, one that includes pronoun noun phrases in its counts, and one that does not.

### 3.4.3.2 Basic index calculation

Basic TAASSC phrasal indices represent the average number of phrasal dependents per phrase type (e.g., the average number of dependents per nominal subject). The sentence *The man*

*in the red hat gave the tall man the money*, for example, includes four nominal phrases, which are a nominal subject, a prepositional object, an indirect object, and a direct object. Together, these four nominal phrases include three determiners, two adjective modifiers, and one prepositional phrase for a total of six phrasal dependents. The average number of adjective modifier dependents per nominal is .5 (2/4).

### 3.4.3.3 *Standard deviations*

For the largest-grained indices, standard deviations are also calculated. In a normal distribution of data, standard deviations indicate how far from the mean values must be to include 68.2% of the data. While a mean value indicates central tendencies in a dataset, standard deviations indicate how well the mean represents the data. Standard deviations are potentially useful in syntactic analysis because they can be used to measure variation.

Overall, TAASSC includes 132 indices of phrasal complexity (and variation). See Table 3.7 for an overview of the phrasal indices.

*Table 3.7 An overview of the phrasal indices included in TAASSC*

Index Type	Average		Standard Deviation		Total
	pronouns	no pronouns	pronouns	no pronouns	
Number of Dependents per Nominal	8	8	8	8	32
Occurrence of particular dependents	10	10			20
Occurrence of particular dependents per particular nominal	40	40			80
Total		116		16	132

### 3.4.4 *Syntactic sophistication*

Indices of syntactic sophistication are grounded in usage-based theories of language acquisition (Ellis, 2002a; Goldberg, 1995; Langacker, 1987). An in-depth treatment of usage-

based perspectives to language development can be found in Chapter 2. This section first describes the reference corpus used, and then describes each index type. TAASSC calculates 15 basic indices of syntactic sophistication. Each basic index includes a number of variations (these are described below), which result in 38 separate indices. Each index is calculated in reference to five subcorpora in COCA (all written, academic, fiction, magazine, & newspaper), resulting in 190 total indices of syntactic sophistication.

#### ***3.4.4.1 Corpus***

Much previous work on VACs has used the British National Corpus (BNC) as a reference corpus (e.g., O'Donnell & Ellis, 2010; Römer et al., 2015). The BNC has a number of advantages as a proxy for language experiences, mostly due to its careful design as a large, balanced, and representative corpus of British English. Adding to its allure is the fact that tagged and dependency parsed versions of the corpus have existed for some time (e.g., Andersen, Nioche, Briscoe, & Carroll, 2008), which aid in the identification of VACs (e.g., O'Donnell & Ellis, 2010). Another large reference corpus is the Corpus of Contemporary American English (COCA; Davies, 2009, 2010). COCA is a balanced corpus of American English that includes texts from works of fiction, popular magazines, newspapers, and academic journals. Additionally, it includes a spoken section comprised of television transcripts. COCA is larger (approximately 450 million words) than the BNC (100 million words) and includes more recently published texts (1990-2012 as opposed to the most recent BNC texts, which were published in 1993). Furthermore, COCA is likely a more appropriate proxy for language use in the primary context of this project (the USA). For these reasons, COCA was chosen as the reference corpus for the current project.

Verb argument constructions in TAASSC are defined as a main verb and all direct dependents that verb takes. In the sentence *John ran quickly* the main verb is *ran*, which takes two direct dependents *John* and *quickly*. *John* is the subject of the verb *ran*, and *quickly* is an adverb that modifies *ran*. The clause *John ran quickly* can be represented by the VAC *nominal subject – verb – adverb modifier*. TAASSC sophistication indices consider the reference-corpus frequency of the lemma form of the main verb (e.g., *run*), the frequency of the VAC, and the frequency with which they occur together. TAASSC also includes indices that calculate the strength of association between main verb lemmas and the VACs they occur in (i.e., faith, delta P, and collocation strength). Each index type is described in the following sections.

#### **3.4.4.2 Frequency**

Frequency indices are calculated for main verb lemmas (see Table 3.8 for the top ten verbs), VACs (see Table 3.9 for the top ten VACs), and main verb lemma – VAC combinations (see Table 3.10 for the top ten combinations). Frequency indices comprise the average frequency score of the target structures (e.g., a VAC) in a particular text. If a particular target structure (e.g., a VAC) that occurs in a text does not occur in the reference corpus, it is not counted toward the index score. These indices measure how frequent the linguistic structures in a text are in reference to their use in COCA.

*Table 3.8 Main verb lemma frequencies in the the written section of COCA*

Rank	Frequency (per million)	Main Verb Lemma
1	160,994.48	be
2	35,711.92	say
3	30,182.42	have
4	15,366.25	make
5	15,229.85	do
6	14,840.33	go
7	13,306.69	get
8	11,900.44	see
9	11,644.46	take
10	11,608.18	know

*Table 3.9 Verb argument construction frequencies in COCA*

Rank	Frequency (per million)	Verb Argument Construction	Most Frequent Main Verb Lemma
1	64,733.43	verb – direct object	make
2	48,780.10	subject – verb – direct object	have
3	34,540.26	subject – verb – nominal complement	be
4	33,315.86	subject – verb – adjective complement	be
5	21,321.88	subject – verb	say
6	20,297.22	subject – verb – clausal complement	say
7	15,960.63	subject – verb – external complement	have
8	11,788.37	verb – clausal complement	say
9	11,117.08	verb	base
10	9,879.52	subordinator – subject – verb – direct object	have

*Table 3.10 Most common verb argument construction-main verb lemma combinations in COCA*

Rank	Frequency (per million)	Main Verb Lemma	Verb Argument Construction	Example (register)
1	34,517.41	be	subject – verb – nominal complement	<i>It is also an indication of the ways...</i> (academic)
2	33,287.74	be	subject – verb – adjective complement	<i>They are very discerning...</i> (news)
3	6,843.83	be	subordinator - subject – verb – adjective complement	She hears <i>that he is arrogant.</i> (news)
4	6,318.98	say	clausal complement – subject – verb	<i>["Andy is an amalgamation of all the douchebags that I've dealt with in my life"], Helms says.</i> (magazine)
5	5,335.93	have	subject – verb – direct object	<i>Iran has obvious interests in Iraq.</i> (magazine)
6	5,124.34	be	verb – nominal complement	That's what's great about <i>being a teen.</i> (news)
7	4,986.51	be	subordinator - subject – verb – nominal complement	Even before the man reached the car, she knew <i>that it was Frank.</i> (fiction)
8	4,258.04	be	verb – adjective complement	This is the reason I have found life <i>to be harder than fiction...</i> (fiction)
9	3,865.16	say	subject – verb – clausal complement	<i>He said [that health decisions should be made by patients and doctors]</i> (magazine)
10	3,516.17	say	clausal complement – verb – subject	<i>["We have an all-new situation now"], says Europol's Storbeck</i> (magazine)

#### **3.4.4.3 Type-token ratio**

Type-token ratios (TTR) are also calculated for main verb lemmas, VACs, and main-verb lemma – VAC combinations. A token count includes the total number of instances of a particular structure in a text (e.g., the total number of VACs in a text). A type count includes the total number of *unique* instances of a particular structure (e.g., the total number of unique VACs in a text). Type-token ratios are calculated by dividing the number of types by the total number of tokens. In TAASSC, any target structures (e.g., a VAC) that do not occur in the reference corpus are not counted towards the index score. These indices measure the diversity of structures used in a text.

#### **3.4.4.4 Attested items**

Indices are also calculated that comprise the percentage of main-verb lemmas, VACs and main-verb lemma – VAC combinations – that occur in a target text occur in the reference corpus. These indices comprise a rough measure of frequency.

#### **3.4.4.5 Association strength**

Strength of association indices measure the conditional probability that two items (in this case a main-verb lemma and a VAC) will occur together. Strength of association has been suggested to supplement (or even be a more appropriate replacement for) frequency in predicting prototypicality and acquisition (Ellis & Ferreira-Junior, 2009a, 2009b). TAASSC calculates three types of association strength measures<sup>2</sup> following previous research including faith (Gries et al.,

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<sup>2</sup> Verb-VAC association strength norms in TAASSC do not include copular constructions (which are very strongly associated with the verb *to be*) to avoid skewing mean association strength scores.

2005), delta P (Ellis & Ferreira-Junior, 2009b), and collostructional strength (Stefanowitsch & Gries, 2003). A 2x2 contingency table is used to calculate the indices of association strength. The contingency table that comprises Table 3.11 will be used in the description of each index below.

*Table 3.11 Contingency table used to calculate various indices of association strength*

	Construction C (nsubj-v-dobj)	Not Construction C (not nsubj-v-dobj)	Totals
Verb V (have)	<b>a</b> (212,970)	<b>b</b> (991,685)	<b>a + b</b> = frequency of V (1,204,655)
Not Verb V (not have)	<b>c</b> (1,733,964)	<b>d</b> (30,909,494)	<b>c + d</b> = combinations that are not V + C (32,643,458)
Totals	<b>a + c</b> (1,946,934) frequency of C	<b>b + d</b> (37,965,533)	<b>(a+b) + (c + d)</b> = N (total number of VAC tokens in the corpus) = (33,635,143)

Note. adapted from Gries et al., 2005

#### 3.4.4.5.1 Faith

Faith calculates the conditional probability that a particular item X will occur given a particular situation Y. Faith values range from 0.0 to 1.0. Higher faith values indicate a higher conditional probability of an outcome given a cue. For our purposes, faith can either be calculated from the perspective of the verb or the construction. For example, we can calculate the probability that a particular VAC X will occur given verb Y (i.e.,  $P(\text{construction}|\text{verb})$ ), which is calculated as:  $\left(\frac{a}{a+b}\right)$  (Gries et al., 2005). The conditional probability that the transitive (SVO) construction will be the outcome given the main verb *have* is  $\frac{212,970}{212,970 + 991,685} = .177$ , indicating that there is a 17.7% chance that the SVO will occur given the main verb *have*. For comparison, the conditional probability that the SVO will occur given the main verb *bisect* is .218, indicating that there is a 21.8% chance the the SVO construction will be cued by the main verb *bisect*. This suggests that *have* is less faithful to SVO than *bisect*.



We can also calculate the probability that a particular VAC  $X$  will occur given a particular verb  $Y$  (i.e.,  $P(\text{verb}|\text{construction})$ ), which is calculated as:  $(\frac{a}{a+c})$ . The conditional probability that the outcome will be the main verb *have* given an SVO construction is calculated  $\frac{212,970}{212,970+1,773,964} = .109$ . This indicates that there is a 10.9% chance that, given the SVO construction, the verb will be *have*. Conversely, the probability that the main verb will be *bisect* given the SVO construction is much smaller (0.00003), suggesting that the SVO is much more faithful to *have* than *bisect*.

#### 3.4.4.5.2 Delta P

Ellis & Ferreira-Junior (2009a, 2009b) utilize the directional probability measure delta P to calculate the strength between a verb and a construction (or vice-versa). Delta P is calculated via the following formula:  $\text{delta P} = P(O|C) - P(O|\neg C)$ , that is, delta P is the probability of an outcome given a cue minus the probability of an outcome without the cue. With reference to Table 3.11, we can calculate delta P with constructions as the outcomes and verbs as the cue via:  $(\frac{a}{a+b}) - (\frac{c}{c+d})$ . To calculate delta P with verbs as the outcomes and constructions as the cue we would simply calculate:  $(\frac{a}{a+c}) - (\frac{b}{b+d})$ . Delta P values range from -1.0 to 1.0. Positive delta P values indicate that an outcome is more likely to occur given a particular cue than it is without the cue.

The delta P value for the outcome of the SVO given the cue *have* is calculated  $(\frac{212,970}{212,970 + 991,685} = .177) - (\frac{1,733,964}{1,733,964 + 30,909,494} = .053) = .124$ . The probability of the outcome SVO given the cue *have* (.177) is larger than the probability that the SVO will be the outcome given another verb cue (.053), resulting in a positive delta P value (.124). The delta P values for SVO as the outcome given *bisect* as the cue is .159, which suggests that *bisect* is more

strongly associated with the SVO than *have*. Delta P values for *have* as the outcome given an SVO cue is .069. This value is higher than the delta P value for *bisect* as the outcome given an SVO cue (.00002), which suggests that *have* is more strongly associated with the SVO than *bisect* is.

#### 3.4.4.5.3 Collostructional Analysis

One potential issue with indices such as faith and  $\Delta P$  is the difference in the strength of association of a particular verb-construction combination depending on the perspective (i.e. verb to construction or construction to verb). From a verb to construction perspective, *bisect* is strongly related to the SVO construction, but from a construction to verb perspective, *bisect* the relationship is quite weak. One alternative association strength measure that addresses this issue is collexeme/collostructional analysis. *Collexeme* analysis (Stefanowitsch & Gries, 2003) measures the joint probability (i.e., it is not directional) that two items in a corpus will co-occur. When collexeme analysis is used to measure the strength of verb-construction combinations, it is termed collostructional analysis (Gries et al., 2005). With reference to the applicable data in Table 3.11, collostructional analysis calculates the likelihood that a verb-construction combination will occur using the Fisher-Yates exact test (Fisher, 1934; Yates, 1934), which is calculated as:  $p_{\text{observed distribution}} = \frac{\left(\frac{a+c}{a}\right) * \left(\frac{b+d}{b}\right)}{\frac{N}{a+b}} + \sum p_{\text{all more extreme distributions}}$ . Gries et al. (2005) used the negative base of ten logarithm of the  $p$  value to rank-order the strength of association between verbs and constructions. Gries et al. (2005) argue that collostructional analysis is superior to verb occupancy frequency counts and faith figures for three reasons beyond the issue of directionality.

First, collocation analysis takes into account both the verb and the construction's overall frequencies. This is important because it controls for the issue of a particular verb having a high occupancy frequency based on the overall high frequency of that verb (i.e., a high frequency verb is going to have a higher probability of being highly frequent in a construction than a low frequency verb). Furthermore, it controls for the tendency for low frequency verbs to have very high faithfulness values. The verb *bisect*, for example, has a 21.8% chance of occurring in the SVO construction, suggesting that (from the perspective of the verb) the *bisect* - SVO combination is highly prototypical, despite the fact that *bisect* only occurs in COCA 64 times (and therefore is probably not actually a prototype verb for the SVO construction). Second, in addition to calculating fine-grained joint probabilities, collocation analysis also provides large grained information by identifying verbs and constructions that are "attracted", "repelled", or have a "neutral" strength of association. Finally, it allows for testing the (statistical) significance of the verb occupancy in a construction. A number of indices can be calculated for a text to determine how prototypical the particular verb/construction combinations are using information from collocation analysis. The strength of collocation analysis, its use of Fisher's exact test, is also its Achilles' heel. Fisher's exact test is very slow when dealing with high frequency items, and most programs that calculate the test end up rounding the values to either "-1" or "1" (the logarithm of which is negative infinity and infinity, respectively). One solution to this issue is to calculate the approximate collocation strength by multiplying the delta P value (construction as cue, verb as outcome) by the frequency of the verb, which correlates almost perfectly with collocation strength (Gries, 2015). TAASSC uses this method, which is represented by the following formula: *approximate collexeme strength* =  $\left( \left( \frac{a}{a+b} \right) - \left( \frac{c}{c+d} \right) \right) * (a + b)$ . Collocation analysis suggests that *have* and *SVO* are strongly

attracted, while *bisect* and *SVO* are weakly attracted. See Table 3.12 for a comparison of the most frequent and most strongly attracted SVO-verb combinations.

*Table 3.12 Strongly attracted SVO – Verb combinations in academic COCA*

Main Verb Lemma	Frequency Rank	Approximate Collexeme Strength Rank
have	1	1
make	2	2
get	3	3
do	4	6
see	5	4
take	6	5
include	7	8
find	8	7
know	9	4498
say	10	4512
provide	11	9
tell	12	12
need	13	10
show	14	11
love	15	14
use	16	4507
give	17	4495
call	18	32
want	19	4504
hear	20	13

#### **3.4.4.6 Variations**

TAASSC calculates three variations for a number of the basic association strength indices (i.e., logarithm transformation, type-only, and standard deviations). Logarithm-transformed versions of the frequency indices are calculated. Logarithm transformation is often used in frequency research to account for the Zipfian nature of language data (Zipf, 1935). Type-only versions of all indices (except TTR) are calculated. Type-only indices are calculated by only counting each unique structure (e.g., a particular VAC) toward the index value once. For example, if a particular text included three instances of the *nominal subject – verb – direct object*

VAC and two instances of the *nominal subject – verb – adjective complement* VAC, a type-only index would be calculated using only one instance of each. Finally, the standard deviation of each index (except TTR) is calculated. In contrast to the mean or average value for a particular index (e.g., main-verb lemma frequency), which demonstrates a central tendency, standard deviation indices provide a measure of variability. See Table 3.13 for an overview of the syntactic sophistication indices calculated by TAASSC.

*Table 3.13 An overview of the syntactic sophistication indices calculated in TAASSC for each subcorpus*

	Main Verb Lemma		VAC		Combinations		Total
	Mean or Ratio	Standard Deviation	Mean or Ratio	Standard Deviation	Mean or Ratio	Standard Deviation	
<b>Frequency</b>	1	1	1	1	1	1	<b>6</b>
<i>Logarithm</i>	1	1	1	1	1	1	<b>6</b>
<i>Types</i>	1		1		1		<b>3</b>
<b>TTR</b>	1		1		1		<b>3</b>
<b>Attested</b>	1		1		1		<b>3</b>
<b>Association Strength</b>					6	5	<b>11</b>
<i>Types</i>					6		<b>6</b>
<b>Total</b>	<b>5</b>	<b>2</b>	<b>5</b>	<b>2</b>	<b>17</b>	<b>7</b>	<b>38</b>

### 3.4.5 Principal component analysis

One strength of TAASSC is the flexibility afforded by the wide range of indices calculated. For some tasks, however, the sheer number of indices may be both overwhelming for the research and/or statistically inappropriate. One method that can be used to reduce a large group of indices into a smaller set of indices (i.e., components) is principal components analysis (PCA) (e.g., Crossley, Kyle, & Mcnamara, 2015; Graesser, McNamara, & Kulikowich, 2011). A PCA clusters indices into groups that co-occur frequently within a particular dataset allowing for a large number of variables to be reduced into a smaller set of derived variables (i.e., the

components). PCA has been used in a number of applications, including (but not limited to) exploring register variation (Biber, 1988), modeling holistic scores of essay quality (Crossley, Kyle, & McNamara, 2015; Friginal & Weigle, 2014), and modelling linguistic development in K-12 education (Graesser et al., 2011).

#### ***3.4.5.1 Method***

Following these studies, and particularly to allow for a wide range of statistical analyses to be conducted using the breadth of indices afforded by TAASSC, a principal components analysis (PCA) was conducted in order to reduce the number of indices in TAASSC to a smaller number of components comprised of related indices. A preliminary correlational analysis suggested that the indices of syntactic sophistication were closely related across the COCA registers. For this reason, the 38 indices derived from the combined COCA written registers represented the indices of syntactic sophistication (that is, the indices that represented each separate register were precluded from the analysis because they were strongly correlated with their respective parallel combined corpus indices). In addition to the 38 indices of syntactic sophistication, the 31 indices of fine-grained clausal complexity and the 132 fine-grained indices of phrasal complexity (a total of 201 indices) were used in the PCA. The 201 TAASSC indices were used in conjunction with a stratified random sample of COCA written texts comprised of 10,000 texts (2,500 from each register) to conduct the PCA. Any indices with non-normal distributions were removed from further consideration. The multicollinearity threshold was set at  $r = .900$  to ensure that variables included in the analysis did not measure the same construct. A conservative eigen cut-off value (.35) was set following Crossley, Kyle, & McNamara (2015) to ensure that only related variables would be included in each component. A Varimax rotation was used to create orthogonal components (e.g., Graesser et al., 2011), which ensures that a set of non-collinear

components are created. After conducting the PCA, the eigen values were then used in the components to calculate weighted component scores.

### ***3.4.5.2 Results***

In total, 201 TAASSC indices related to syntactic complexity sophistication were considered in the PCA. Of the 201 indices, 68 were non-normally distributed. Of the 131 normally distributed indices, 52 were removed due to multicollinearity. The remaining 79 normally distributed and non-collinear indices were entered into the PCA. The PCA reported 23 components with initial eigenvalues over 1. Within the Varimax rotated components, there was a break in the cumulative variance explained between the ninth and tenth component, suggesting that the first nine components explained the largest amount of the variance. These nine components, which are comprised of 60 TAASSC indices, explained approximately 56% of the shared variance in the data for the rotated components. Considering this break, a 9-component solution was selected. Each of these components and the indices that inform them are discussed below.

#### ***3.4.5.2.1 Component 1: Noun phrase elaboration***

The first component seemed to capture noun phrase elaboration. This component includes 19 indices that mostly capture noun phrase elaboration in general, and prepositions, adjectives, determiners, and verbal modifiers of nominals specifically. A text that earned a high score for this component would include noun phrases with a higher degree of elaboration. The indices included in the noun phrase elaboration component and their Eigen loadings are provided in Table 3.14.

*Table 3.14 Component 1: Noun phrase elaboration*

Variable Name	Eigen Loading
prepositions per nominal	0.916
dependents per object of the preposition	0.874
prepositions per object of the preposition	0.778
prepositions per direct object	0.777
prepositions per nominal subject	0.765
adjectival modifiers per nominal	0.752
dependents per nominal	0.722
dependents per nominal subject	0.658
adjectival modifiers per nominal subject	0.649
adjectival modifiers per object of the preposition	0.637
adjectival modifiers per direct object	0.627
determiners per nominal subject	0.614
passive nominal subjects per clause	0.590
dependents per direct object (no pronouns)	0.553
dependents per object of the preposition (no pronouns)	0.548
prepositions per clause	0.543
verbal modifiers per nominal	0.516
nominal subjects per clause	-0.468
dependents per nominal complement	0.405

#### 3.4.5.2.2 Component 2: Verb-VAC frequency

The second component seemed to capture verb-VAC frequency. This component captures verb and verb – VAC frequency. A text that earns a high score for this component will tend to include more frequent main verb lemmas and main verb lemma – VAC combinations. Accordingly, it may also include more adjective complements and nominal complements (i.e., copular constructions), which tend to occur frequently. The indices included in the verb-VAC frequency component and their Eigen loadings are provided in Table 3.15.



*Table 3.15 Component 2: Verb-VAC frequency*

Variable Name	Eigen Loading
average lemma construction combination frequency - all	0.908
average lemma frequency - all	0.908
average lemma construction combination frequency, log transformed - all (standard deviation)	0.852
average lemma frequency, log transformed – all (standard deviation)	0.850
average lemma construction combination frequency, log transformed - all	0.728
nominal complements per clause	0.728
average lemma frequency (types only) - all	0.706
adjective complements per clause	0.560

#### 3.4.5.2.3 Component 3: Nouns as modifiers and modifier variation

The third component seemed to capture nouns as modifiers and modifier variation. This component captures the use of nouns as nominal modifiers in general and specifically direct object and nominal subject modifiers. Additionally, this component captures variation in the number of modifiers per nominal, both for nominals in general and specifically for prepositional objects, direct objects, and nominal subjects. A text that earned a high score for this component would include a higher number of nouns as modifiers and have a wider variation in the number of dependents per nominal. The indices included in the nouns as modifiers and modifier variation component and their Eigen loadings are provided in Table 3.16.

*Table 3.16 Component 3: Nouns as modifiers and modifier variation*

Variable Name	Eigen Loading
nouns as a nominal dependent per nominal	0.810
nouns as a direct object dependent per direct object	0.797
dependents per nominal (standard deviation)	0.789
nouns as a nominal subject dependent per nominal subject (no pronouns)	0.727
dependents per object of the preposition (standard deviation)	0.667
dependents per direct object (standard deviation)	0.586
dependents per nominal subject (standard deviation)	0.576

#### 3.4.5.2.4 Component 4: Determiners

The fourth component seemed to capture determiner use. This component captures the use of determiners in noun phrases in general, and in objects of the preposition, direct objects, and nominal subjects in particular. A text that earned a high score for this component would include a higher number of determiners such as *the, a, an, this, these*, etc. The indices included in the determiners component and their Eigen loadings are provided in Table 3.17.

*Table 3.17 Component 4: Determiners*

Variable Name	Eigen Loading
determiners per nominal (no pronouns)	0.947
determiners per nominal	0.849
determiners per object of the preposition	0.819
determiners per direct object	0.719
determiners per nominal subject (no pronouns)	0.630

#### 3.4.5.2.5 Component 5: VAC frequency and direct objects

The fifth component seemed to capture VAC frequency and direct object use. This component captures the frequency of VACs, the incidence of direct objects, and the incidence of direct object dependents. A text that earned a high score on this component would include more frequent VACs, and would include more direct objects per clause and more dependents per direct object. The indices included in the VAC frequency and direct objects component and their Eigen loadings are provided in Table 3.18.

*Table 3.18 Component 5: VAC frequency and direct objects*

Variable Name	Eigen Loading
average construction frequency - all	0.884
average construction frequency (types only) - all	0.867
average construction frequency, log transformed - all	0.710
direct objects per clause	0.490
dependents per direct object	0.445

#### 3.4.5.2.6 Component 6: Association strength

The sixth component seemed to capture verb-VAC association strength. This component captures main verb lemma – VAC association strength. A text that earns a high score for this component will include main verb lemma – VAC combinations that are strongly associated. Additionally, a text that earns a high score for this component may also include more clausal complements per clause, suggesting a link between the strength of main verb lemma – VAC associations and the use of clausal complements. The indices included in the Association strength component and their Eigen loadings are provided in Table 3.19.

*Table 3.19 Component 6: Association Strength*

Variable Name	Eigen Loading
average approximate collostructional strength - all	0.924
average approximate collostructional strength (types only) - all	0.894
average delta p score construction (cue) - verb (outcome) (types only) - all	0.825
clausal complements per clause	0.629

#### 3.4.5.2.7 Component 7: Diversity and frequency

The seventh component seemed to capture diversity and frequency. This component captures diversity of verb argument constructions (VACs), main verb lemmas, and main verb lemma – VAC combinations. It also captures main verb lemma – VAC frequency. A text that earns a high score for this component will have high diversity of VACs, verbs, and verb – VAC combinations, and on average will also include more frequent verb – VAC combinations. The indices included in the diversity and frequency component and their Eigen loadings are provided in Table 3.20.

*Table 3.20 Component 7: Diversity and frequency*

Variable Name	Eigen Loading
construction type-token ratio - all	0.926
main verb lemma type-token ratio - all	0.872
lemma construction combination type-token ratio - all	0.792
average lemma construction frequency (types only) - all	0.655

#### 3.4.5.2.8 Component 8: Possessives

The eighth component seemed to capture possessives. This component captures the use of possessives in general, and specifically captures the use of possessives in nominal subjects, direct objects, and prepositional objects. A text that earned a high score on this component would include a high number of possessives, such as *my*, *his*, *her*, *their*, etc. The indices included in the possessives component and their Eigen loadings are provided in Table 3.21.

*Table 3.21 Component 8: Possessives*

Variable Name	Eigen Loading
possessives per nominal	0.904
possessives per nominal subject	0.734
possessives per direct object	0.718
possessives per object of the preposition	0.711

#### 3.4.5.2.9 Component 9: Frequency

The ninth component seemed to capture frequency. This component captures VAC, main verb lemma, and main verb lemma – VAC combination frequency. A text that earned a high score for this component would include a higher percentage of VACs and main verb lemma – VAC combinations that are attested in the written section of COCA. Additionally, a text that earned a high score for this component would on average include more frequent VACs and main verb lemmas. The indices included in the frequency component and their Eigen loadings are provided in Table 3.22.

*Table 3.22 Component 9: Frequency*

Variable Name	Eigen Loading
percentage of constructions in text that are in reference corpus - all	0.873
percentage of lemma construction combinations in text that are in reference corpus - all	0.838
average construction frequency, log transformed - all	0.647
average lemma frequency, log transformed - all	0.642

### 3.5 Conclusion

TAASSC represents the nexus of current issues in second language acquisition (Bulté & Housen, 2012; Ellis et al., 2014), second language writing (Lu, 2011; Norris & Ortega, 2009; Ortega, 2015; Wolfe-Quintero et al., 1998) and recent advancements in natural language processing (Chen & Manning, 2014). TAASSC includes time-tested indices of syntactic complexity (Lu, 2011; Ortega, 2003; Wolfe-Quintero et al., 1998), and fine-grained indices of syntactic complexity at phrasal and clausal levels (Norris & Ortega, 2009). TAASSC also includes indices related to usage-based theories of language acquisition (Ellis, 2002a; Goldberg, 1995; Langacker, 1987; Römer et al., 2015). TAASSC is freely available, requires no programming knowledge to use, employs a parser with state of the art accuracy (Chen & Manning, 2014), and works on all major operating systems. Chapter 4 reports on the relationship between TAASSC indices of syntactic complexity and sophistication and L2 writing quality. Chapter 5 reports on investigations between TAASSC indices of syntactic complexity and sophistication and one year of language instruction.

#### **4 THE RELATIONSHIP BETWEEN SYNTACTIC COMPLEXITY AND SOPHISTICATION AND L2 WRITING QUALITY**

Syntactic complexity has been of interest to the field of L2 writing for over 45 years. Much of the research in this area has focused on a small number of relatively large-grained indices (e.g., mean length of clause, mean length of T-unit). The results, however, have been mixed (e.g., Ortega, 2003; Wolfe-Quintero et al., 1998), resulting in a lack of consensus regarding the relationship between syntactic complexity and L2 writing quality. This chapter re-examines the relationship between syntax and L2 writing quality using both established indices of syntactic complexity and newly developed, fine-grained indices of syntactic complexity and sophistication. Specifically, the relationship between indices of syntactic development are used to predict holistic scores of timed TOEFL independent essays. Traditional large-grained (e.g., mean length of clause) indices of syntactic complexity, in addition to newly developed fine-grained clausal and phrasal indices of syntactic complexity and frequency-based indices of syntactic sophistication are used to predict holistic scores of writing quality.

This chapter is guided by research questions 1a – 5a:

- 1a. What is the relationship between the Syntactic Complexity Analyzer indices and holistic scores of writing proficiency?
- 2a. What is the relationship between fine-grained indices of clausal complexity and holistic scores of writing proficiency?
- 3a. What is the relationship between fine-grained indices of phrasal complexity and holistic scores of writing proficiency?
- 4a. What is the relationship between fine-grained indices of phrasal complexity and holistic scores of writing proficiency?

5a. What is the relationship between all syntactic development indices included in TAASSC and holistic scores of writing proficiency?

First the various indices of syntactic complexity and sophistication are briefly discussed, followed by a description of the learner corpus of essays used. The statistical analyses employed to answer the research questions are then discussed, followed by a report of the results. Finally, implications of the results are discussed.

## **4.1 Method**

### **4.1.1 Indices**

TAASSC calculates four types of indices. The first type includes the indices of syntactic complexity that are included in Lu's (2010, 2011) Syntactic Complexity Analyzer (SCA) and address research question 1a. The second type comprises fine-grained indices of clausal complexity and address research question 2a. The third type comprises fine-grained indices of phrasal complexity and address research question 3a. The fourth and final type comprises frequency-based indices of syntactic sophistication and address research question 4a. See Chapter 3 for an in-depth description of all indices included in TAASSC.

### **4.1.2 Writing proficiency corpus**

The written proficiency corpus is comprised of argumentative essays written as part of the Test of English as a Foreign Language (TOEFL). The essays comprise responses to two independent prompts (240 texts each) that ask test-takers to compose an essay that asserts and defends an opinion on a particular topic based on life experience (see Table 4.1). Test-takers are given 30 minutes to complete the writing task, and are expected to produce at least 300 words. See Table 4.2 for an overview of this corpus.

*Table 4.1 Writing prompts for independent essays in TOEFL public use dataset*

Test Form	Prompt Instructions
1	Do you agree or disagree with the following statement? It is more important to choose to study subjects you are interested in than to choose subjects to prepare for a job or career. Use specific reasons and examples to support your answer.
2	Do you agree or disagree with the following statement? In today's world, the ability to cooperate well with others is far more important than it was in the past. Use specific reasons and examples to support your answer.

*Table 4.2 Overview of writing proficiency corpus*

Prompt	N	Number of Words	Mean Score	Standard Deviation
1	240	77,238	3.83	0.86
2	240	74,252	3.47	0.91

Each essay was given a score on a 5-point scale by at least two raters trained by ETS. If the scores given by the raters differed by 1 point or less, scores were averaged. If any two scores given by raters differed by more than 1 point, a third rater was used to adjudicate the score. Scores range from 1.0 to 5.0 in .5 point intervals. The holistic rating score used included descriptors related to the completion of the task, organization, development of ideas, coherence, word use, and syntax. See Table 4.3 for the score descriptors for low and high proficiency essays. See Appendix A for the complete rating scale.



*Table 4.3 Abbreviated TOEFL rubric for independent writing tasks*

Score	Descriptors
5	An essay at this level largely accomplishes all of the following: effectively addresses the topic and task is well organized and well developed, using clearly appropriate explanations, exemplifications, and/or details displays unity, progression, and coherence displays consistent facility in the use of language, demonstrating syntactic variety, appropriate word choice, and idiomaticity, though it may have minor lexical or grammatical errors
2	An essay at this level may reveal one or more of the following weaknesses: limited development in response to the topic and task inadequate organization of connection of ideas inappropriate or insufficient exemplifications, explanations, or details to support or illustrate generalizations in response to the task a noticeably inappropriate choice of words or word forms an accumulation of errors in sentence structure and/or usage

### 4.1.3 Statistical analysis

In order to determine how writing quality differs across writing levels in TOEFL independent essays, a multiple linear regression analysis was conducted for each index type<sup>3</sup>. First, normality was checked using the visualization component of the WEKA statistical package (Hall et al., 2009). Any variables that violated a normal distribution were discarded. In most cases, discarded variables represented syntactic features that occurred extremely rarely in the data (and therefore were not candidates for transformation) such as indirect objects and relative clauses. Pearson correlations were then conducted on the remaining variables to determine whether they were meaningfully correlated with holistic essay score. Any variables that did not reach an absolute correlation value of  $r \geq .100$  with holistic essay score (which represents the threshold for a “small” effect [Cohen, 1988]) were removed from further consideration. Next, the

<sup>3</sup> This study examines whether linear relationships exist between linguistic features and language proficiency. That linguistic development may not be strictly linear and is likely affected by a number of factors (e.g., is a complex adaptive system [Larsen-Freeman & Cameron, 2008]) is acknowledged. Linear analyses are used in order to find simple explanations, which may serve as a starting point for future analyses of factors which mitigate variability in language learning.

remaining variables were checked for multicollinearity to ensure that final model consisted only of unique indices and that multicollinear indices did not exaggerate the results of the multiple regression analysis (Tabachnick & Fidell, 2014). For each pair of variables with absolute correlation values of  $r \geq .700$ , only the variable with the highest correlation with holistic score was kept (Crossley, Salsbury, & McNamara, 2012).

The remaining variables were entered into a ten-fold cross-validation multiple regression using the WEKA statistical package. Ten-fold cross-validation is a method designed to avoid overfitting a statistical or machine-learning model (Witten & Frank, 2005). In a 10-fold cross-validation multiple regression, the dataset is randomly divided into ten sections (called “folds”). A stepwise multiple regression is conducted using nine of the ten folds to train a statistical model, which is then tested on the remaining fold. This procedure is repeated nine more times until all of the folds have served as the test set. Finally, each of the ten models is averaged. After the 10-fold multiple regression was conducted, a follow-up regression using the averaged model was conducted in SPSS on the entire dataset. The next step in the statistical analysis was to determine how generalizable the model was across topics by comparing the multiple regression models between prompts using a Fisher  $r$  to  $z$  transformation. This analysis tests whether the differences between two correlation values are due to chance (Dunn & Clark, 1969).

The accuracy of the model was also evaluated by calculating the exact and adjacent matches between actual holistic score and the score predicted by the model. This is a common way to evaluate the accuracy of automatic essay scoring algorithms (Shermis & Burstein, 2003). Exact matches include predicted scores that match the actual score, while predicted and actual scores are considered to be adjacent matches when they only differ by a prescribed number of points. For all analyses in this study, predicted scores are considered to be adjacent matches if

the are within 1 point of the actual score. To facilitate this evaluation, all scores were rounded to the nearest whole number (Shermis & Burstein, 2003). Kappa statistics were also conducted on the rounded scores to estimate the strength of agreement between the actual scores and the predicted scores (Landis & Koch, 1977).

## 4.2 Results and Discussion

### 4.2.1 Research Question 1a: Syntactic Complexity Analyzer

#### 4.2.1.1 Results: Syntactic Complexity Analyzer

First, the potential for the 14 indices in Lu's (2010, 2011) SCA to explain the variance in holistic scores of essay quality in TOEFL independent essays was explored. All 14 indices demonstrated normal distributions. Eight of these did not reach the minimum correlation threshold of  $r \geq 0.100$  with TOEFL essay quality scores and were removed from the analysis. Of the remaining six variables, three were removed due to multicollinearity with other variables. The remaining three variables (mean length of clause, coordinate phrases per clause, and complex nominals per T-unit) were entered into a 10-fold stepwise regression (see Table 4.4 for an overview of these variables). The resulting model, which included one variable (mean length of clause), explained 4.0% ( $r = .200$ ,  $R^2 = .040$ ) of the variance in holistic essay scores (see Table 4.5 for the model). When the 10-fold model was applied to the entire dataset, it yielded a significant model ( $F(1, 478)$ ,  $p < .001$ ), which explained 5.8% ( $r = .240$ ,  $R^2 = .058$ ) of the variance. The model explained 2.7% ( $r = .163$ ,  $R^2 = .027$ ) of the variance in prompt 1 scores and 8.9% ( $r = .298$ ,  $R^2 = .089$ ) of the variance in prompt 2 scores. A Fisher's r to z transformation indicated that the amount of variance explained by the model across the two prompts did not differ significantly ( $z = -1.56$ ,  $p = .119$ ). The exact accuracy of the scores predicted by the model

was 37.3%, and the exact/adjacent accuracy was 87.9%. The reported Kappa = .174 suggests slight agreement between the actual and predicted scores (Landis & Koch, 1977).

*Table 4.4 Correlations between holistic essay score and SCA variables entered into regression model*

Variable	Correlation with Holistic Score
mean length of clause	0.240
coordinate phrases per clause	0.190
complex nominals per T-unit	0.124

*Table 4.5 Summary of SCA multiple regression model*

Entry	Predictors included	<i>B</i>	$\beta$	<i>SE</i>	<i>T</i>	<i>p</i>
1	mean length of clause	.240	.110	.020	5.407	< .001

*Note.* Estimated constant term = 2.360,  $\beta$  = unstandardized beta, *SE* = standard error; *B* = standardized beta.

#### **4.2.1.1 Discussion: Syntactic Complexity Analyzer**

The relationship between indices of syntactic complexity calculated by the Syntactic Complexity Analyzer (SCA) and TOEFL independent essay scores was significant, but small. A number of the indices calculated by SCA were collinear (e.g., complex nominals per T-unit and mean length of T-unit), supporting Lu's (2010, 2011) findings. Three of the fourteen indices of syntactic complexity, including mean length of clause (MLC), coordinate phrases per clause (CP/C) and complex nominals per T-unit (CN/T) were non-collinear and demonstrated small, but meaningful correlations with essay scores. One index, MLC was included in a model that explained 4.0% of the variance in essay scores. See Table 4.7 for examples of MLC from low and high scoring essays.

*Table 4.6 Examples from TOEFL Essays: Mean length of clause*

Score	Example	Length of Clause
1	I selected agree to this question.	6
	Because I regret it.	4
		<b>Mean = 5</b>
5	With this in mind, it is still possible to argue that	11
	colleges do not exist for the sole purpose of producing effective social agents	13
		<b>Mean = 12</b>

Essays that tended to have longer clauses, more coordinate phrases per clause, and more complex nominals per T-unit tended to earn higher scores. These findings support previous studies, such as Lu (2010, 2011), who found similar results across university levels (i.e., as university level increased, writers used longer clauses, more coordinate phrases per clause, and more complex nominals per T-unit). These results also align with the findings from Ortega's (2003) synthesis of L2 writing studies, which found either neutral or positive relationships between MLC and writing proficiency. Overall, however, these differences demonstrated small effects and explained only a small portion of the variance in holistic scores of writing proficiency. Furthermore, the regression model included a single index (MLC). Accordingly, their predictive performance was quite low, as demonstrated by exact and adjacent matches between predicted and actual scores and quadratic weighted kappa statistics. The model explained more of the variance in prompt 2 scores (8.9%) than in prompt 1 scores (2.7%), but the results of a Fisher's r to z transformation indicates that these differences are not significant.

The nature of the issue of multicollinearity in this case is also important to note. Of the six variables that demonstrated meaningful relationships with holistic score, half were strongly

correlated. Both mean length of unit indices (MLC and MLT) demonstrated correlations above  $r = .800$  with their complex nominal counterpart (CN/C and CN/T). This suggests that increase in clause and T-unit length is likely due to the inclusion of more complex nominals. The range of structures included as complex nominals, however is quite broad, ranging in complexity from nouns with adjectives to nominal clauses, which obscures the types of structures being produced.

## 4.2.2 Research Question 2a: Fine-grained clausal complexity

### 4.2.2.1 Results: Fine-grained clausal complexity

Next, the potential for 31 fine-grained clausal complexity indices to explain the variance in holistic scores of essay quality in TOEFL independent essays was explored. Sixteen of the indices violated the assumption of normality and were removed from further consideration. Nine of the remaining 15 variables did not reach the minimum correlation threshold of  $r \geq 0.100$  and were removed from further consideration. The six remaining indices (see Table 4.7) were entered into a 10-fold stepwise regression. The resulting model, which included four variables, explained 2.8% ( $r = .166$ ,  $R^2 = .028$ ) of the variance in holistic essay scores (see Table 4.8 for the model). When the 10-fold model was applied to the entire dataset, it yielded a significant model ( $F(4, 475)$ ,  $p < .001$ ), that explained 6.4% ( $r = .254$ ,  $R^2 = .064$ ) of the variance. The model explained 3.8% ( $r = .196$ ,  $R^2 = .038$ ) of the variance in prompt 1 scores and 8.8% ( $r = .296$ ,  $R^2 = .088$ ) of the variance in prompt 2 scores. A Fisher's  $r$  to  $z$  transformation indicated that the amount of variance explained by the model across the two prompts did not differ significantly ( $z = -1.16$ ,  $p = .246$ ). The exact accuracy of the scores predicted by the model was 40.2%, and the exact/adjacent accuracy was 86.9%. The reported quadratic weighted Kappa = .151, suggests slight agreement between the actual and predicted scores (Landis & Koch, 1977).

*Table 4.7 Correlations between holistic essay score and clausal complexity variables entered into regression*

Variable	Correlation with Holistic Score
nominal subjects per clause	-0.172
prepositions per clause	0.141
direct objects per clause	-0.137
dependents per clause (standard deviation)	0.128
adverbial modifiers per clause	0.116
clausal complements per clause	-0.106

*Table 4.8 Summary of clausal complexity multiple regression model*

Entry	Predictors included	<i>r</i>	<i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup> change	$\beta$	<i>SE</i>	<i>B</i>
1	nominal subjects per clause	.172	.030	.030	-1.230	.438	-.129
2	direct objects per clause	.209	.044	.014	-1.084	.373	-.130
3	dependents per clause (standard deviation)	.240	.054	.014	.617	.230	.119
4	clausal complements per clause	.254	.064	.007	-1.319	.714	-.084

*Note.* Estimated constant term = 4.028,  $\beta$  = unstandardized beta, *SE* = standard error; *B* = standardized beta.

#### **4.2.2.1 Discussion: Fine-grained clausal complexity**

The relationship between fine-grained indices of clausal complexity and writing scores was significant but small. Over half of the indices violated the assumption of normality due to their rare occurrence in TOEFL essays (e.g., indirect objects and clausal coordinating conjunctions). Eight indices (e.g., modals per clause and adverb modifiers per clause) did not demonstrate a meaningful relationship with essay quality. Six non-collinear variables were entered into a stepwise multiple regression. The resulting model, which included four indices, explained 6.4% of the variance in holistic essay scores.

The results suggest that essays that include fewer nominal subjects, direct objects, and finite clausal complements per clause, and a wider range of dependents per clause tend to earn higher scores. With the exception of the SCA indices, TAASSC counts both finite and non-finite verb phrases as clauses. The negative correlation between nominal subjects, direct objects per

clause, and finite clausal complements and essay score suggests a positive relationship between the inclusion of non-finite clauses (such as infinitive and gerund clauses) and essay score. Table 4.11 includes examples from a high-scoring essay that demonstrate the use of non-finite clauses.

*Table 4.9 Examples of non-finite clauses in high-scoring essays*

Construction	Example
verb – clausal complement	<i>It is our responsibility <b>[to make]</b><sub>infinitive verb</sub> <b>[our children understand...]</b><sub>clausal complement</sub></i>
verb – direct object	<i>The issue of deciding to choose and <b>start</b></i> <sub>infinitive verb</sub> <i><b>[a career]</b></i> <sub>direct object</sub>
adverb modifier – verb – direct object	<i>Parents can contribute by signaling teachers about <b>how</b></i> <sub>adverb modifier</sub> <i><b>to teach</b></i> <sub>infinitive verb</sub> <i><b>their children</b></i> <sub>direct object</sub>

The results also suggest that essays with a wider variation of dependents per clause (but not a higher average number of dependents per clause) tend to earn higher scores. This indicates that including a range of both shorter and longer clauses (as measured by number of clausal dependents) is a better writing strategy than essays including only long (or short) clauses. The use of standard deviations in operationalizing syntactic complexity is novel, though some NLP tools do report standard deviations for lexical sophistication (e.g., Coh-Metrix). The standard deviation does, however, align felicitously with the TOEFL independent writing rubric, which includes descriptors related to syntactic variation.

Overall, the predictive model was significant but only explained a relatively small portion of the variance in essay scores, and, accordingly, predicted scores only demonstrated slight agreement with actual scores. This suggests that clausal complexity, as measured by the number of dependents (and the variation in number of dependents) are not strong predictors of essay quality. This finding supports Biber et al.'s (2011) suggestion that clausal complexity is not a characteristic feature of academic writing. This finding also aligns with Biber et al.'s (2014) findings, in which only a single clausal complexity index (incidence of verb + that clauses)



demonstrated a significant relationship with TOEFL writing quality. Clausal complexity does not appear to be a particularly distinguishing factor between low and high proficiency writers. If a strong relationship exists between syntactic development and writing proficiency, it likely lies elsewhere.

### 4.2.3 Research Question 3a: Phrasal complexity

#### 4.2.3.1 Results: Phrasal complexity

Next, the potential for the 132 medium and fine-grained phrasal complexity indices to explain the variance in holistic scores of essay quality in TOEFL independent essays was explored. 90 indices violated the assumption of normality and were removed from further consideration<sup>4</sup>. Nine of the remaining 42 variables did not reach the minimum correlation threshold of  $r \geq 0.100$  and were removed from further consideration. Of the remaining 33 variables, 16 were removed due to multicollinearity. The remaining 17 variables (see Table 4.10) were entered into a 10-fold stepwise regression. An initial model included three variables with switched signs. These variables were removed and the model was re-run with 14 variables. The resulting model, which included six variables, explained 16.1% ( $r = .400$ ,  $R^2 = .161$ ) of the variance in holistic essay scores (see Table 4.11 for the model). When the 10-fold model was applied to the entire dataset, it yielded a significant model ( $F(6, 473)$ ,  $p < .001$ ), that explained 20.0% ( $r = .447$ ,  $R^2 = .200$ ) of the variance. The model explained 15.7% ( $r = .396$ ,  $R^2 = .157$ ) of the variance in prompt 1 scores and 24.9% ( $r = .499$ ,  $R^2 = .249$ ) of the variance in prompt 2 scores. A Fisher's  $r$  to  $z$  transformation indicated that the amount of variance explained by the model across the two prompts did not differ significantly ( $z = -1.41$ ,  $p = .159$ ). The exact

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<sup>4</sup> Note. Most of the indices removed for violation of normality were counts of features that were rare in the dataset, resulting in the majority of essays receiving index scores of "0".

accuracy of the scores predicted by the model was 42.9%, and the exact/adjacent accuracy was 92.5%. The reported quadratic weighted Kappa = .336 suggests fair agreement between the actual and predicted scores (Landis & Koch, 1977).

*Table 4.10 Correlations between holistic essay score and phrasal complexity variables entered into regression*

Variable	Correlation with Holistic Score
dependents per nominal	0.332
dependents per object of the preposition (no pronouns)	0.290
prepositions per nominal (no pronouns)	0.288
prepositions per object of the preposition	0.287
dependents per nominal (standard deviation)	0.277
dependents per object of the preposition	0.267
adjectival modifiers per object of the preposition	0.265
dependents per direct object (standard deviation)	0.259
dependents per object of the preposition (no pronouns, standard deviation)	0.239
dependents per nominal subject (standard deviation)	0.230
dependents per direct object (no pronouns)	0.226
determiners per nominal subject	0.203
determiners per nominal (no pronouns)	0.157
dependents per direct object	-0.154
adjectival modifiers per direct object (no pronouns)	0.146
determiners per direct object (no pronouns)	0.116
prepositions per direct object	0.110

*Table 4.11 Summary of phrasal complexity multiple regression model*

Entry	Predictors included	$r$	$R^2$	$R^2$ change	$\beta$	$SE$	$B$
1	dependents per object of the preposition (no pronouns)	.290	.084	.084	.669	.187	.164
2	prepositions per object of the preposition	.346	.120	.036	1.526	.592	.121
3	dependents per direct object (standard deviation)	.396	.157	.037	.698	.185	.177
4	dependents per nominal subject (standard deviation)	.427	.182	.025	.445	.170	.117
5	dependents per direct object (no pronouns)	.429	.184	.001	.271	.141	.099
6	dependents per direct object	.447	.200	.016	-.374	.120	-.147

*Note.* Estimated constant term = 1.531,  $\beta$  = unstandardized beta,  $SE$  = standard error;  $B$  = standardized beta.

#### 4.2.3.2 Discussion: Phrasal complexity

The relationship between fine-grained indices of phrasal complexity and writing scores was significant and demonstrated a medium effect. The analysis indicated that a number of the structures examined in TAASSC were rare in TOEFL independent essays, leading to non-normal distributions and the exclusion of their related indices. Indirect objects, for example, were extremely rare in the data, as were passive constructions. Seventeen non-collinear indices that demonstrated meaningful correlations with essay score were entered into a stepwise regression. The resulting model, which explained 20% of the variance in essay scores, included six indices of phrasal complexity. The findings support Biber et al.'s (2011) general hypothesis that as writers develop, their writing will be characterized by complex noun phrases. The specific structures that emerged as important predictors of writing quality included some features Biber et al. suggested would emerge later in L2 development (e.g., phrasal embedding), but precluded others (e.g., relative clauses). The phrasal complexity index with the strongest relationship with holistic writing proficiency scores (number of dependents per nominal), along with each index included in the predictor model is discussed below, followed by a summary of the findings.

##### 4.2.3.2.1 Number of dependents per nominal

The medium-grained index, number of dependents per nominal, demonstrated the highest correlation with essay score ( $r = .332$ ), but was not included in the predictor model. This positive correlation suggests that higher rated essays tend to include nominal phrases with more dependents. For example, a highly rated essay is likely to include the following object of the proposition: *I grew up in [a **family** of businessmen]*, which includes two direct dependents (a determiner and a prepositional phrase). See Figure 4.1 for a visualization of this example. As writers become more proficient, their writing becomes more like academic writing, in which a

great deal of meaning is embedded in noun phrases (Biber et al., 2011). Generally, this result aligns with previous studies that have found a positive relationship between the related Coh-Metrix index modifiers per noun phrase and writing quality (e.g., Guo et al., 2013).

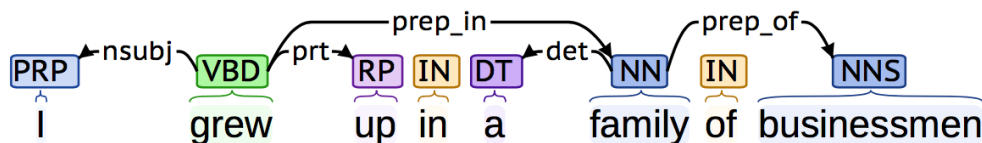


Figure 4.1 Phrasal complexity: Dependents per nominal

#### 4.2.3.2.2 Complexity and prepositional objects

The results suggest that highly rated essays tend to include more dependents per object of the preposition (see Figure 4.2 **Error! Reference source not found.**) and specifically more prepositions per object of the preposition (see Figure 4.3 **Error! Reference source not found.**). The two indices dependents per object of the preposition (no pronouns) and prepositions per object of the preposition together explain a majority of the variance in writing proficiency scores explained by the phrasal complexity model. The findings align with Biber et al.'s (2011) model of writing development, wherein one characteristic of the highest level of development is phrasal embedding (and particularly strings of postmodifier prepositional phrases). As writers become more proficient, their writing more closely models the features of academic writing.

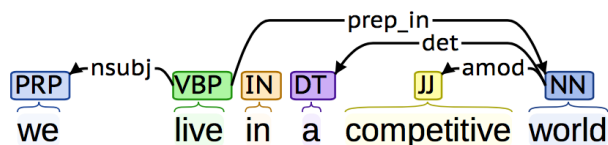


Figure 4.2 Phrasal complexity: Dependents per object of the preposition

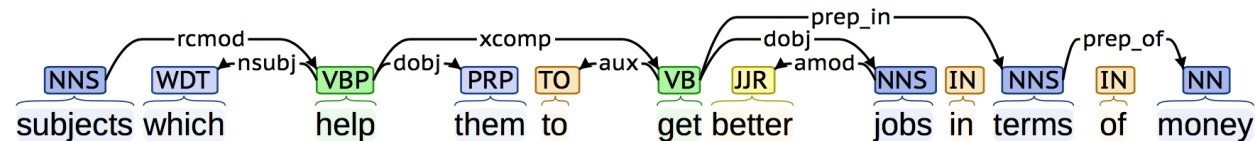


Figure 4.3 Phrasal complexity: Prepositions per object of the preposition

#### 4.2.3.2.3 Complexity and nominal subjects

Essays that included a wider range of dependents per nominal subject tended to earn a higher score. As with the clausal complexity, the results suggest that including only nominal subjects with few or many dependents is not a productive writing strategy. The example sentences in Figure 4.4 **Error! Reference source not found.**, which come from an essay that earned a high score, include both nominal subjects without any dependents (e.g., *it*), and a nominal subject with multiple dependents (i.e., *theme*, which has four direct dependents).

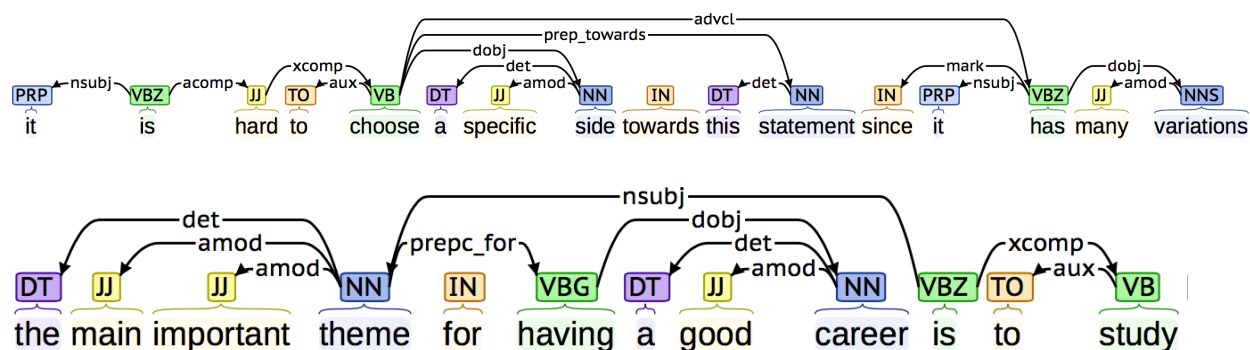


Figure 4.4 Phrasal variation: Dependents per nominal subject

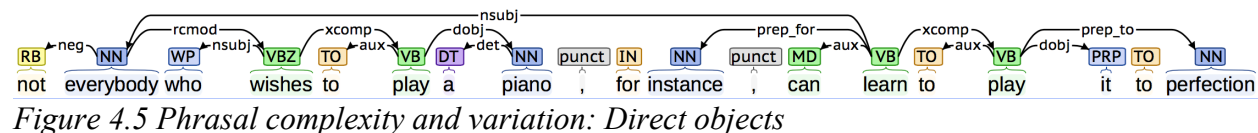
These results are novel, in that previous research has not explored syntactic variation at the phrasal level. Biber et al.'s (2011) corpus analysis of spoken and academic texts, for example, looked at a number of fine-grained phrasal complexity indices, but not variation. The results do align with the TOEFL rubric descriptors, which indicate that high proficiency essays should include a variety of syntactic structures.

One would expect that standard deviation scores for complexity indices would be correlated with mean scores. In order for a writer to use a wider range of dependents per nominal subject, for example, one must include some structures with multiple dependents per nominal (which would also increase the mean number of dependents per nominal). In the data,

dependents per nominal subject index was strongly correlated ( $r = .840$ ) with the dependents per nominal index (standard deviation). Considering this relationship, the results provide further evidence that as writers become more proficient, their writing includes more features of academic writing (Biber et al., 2011). In this light, the results may also align with studies that have demonstrated a relationship with the Coh-Metrix index number of words before the main verb and writing quality (e.g., Crossley & McNamara, 2014; McNamara et al., 2010).

#### 4.2.3.2.4 Complexity and direct objects

Essays that included a wider range of dependents per direct object, more dependents per direct object (ignoring direct objects that are pronouns) and fewer dependents per direct object (when pronouns are considered) tend to earn higher writing proficiency scores. This suggests that highly rated essays tend to include both complex direct object phrases (e.g., *a piano* in Figure 4.5 **Error! Reference source not found.**) and direct object phrases with no dependents (e.g., *it* in Figure 4.5 **Error! Reference source not found.**). As writers develop, they seem to have a wider range of direct object structures at their disposal, and employ both pronominal direct objects (which have no direct dependents) and direct objects with dependents. This finding is novel, both with regard to the exploration of direct object complexity, and, accordingly, to the use of standard deviations. The Biber et al. (2011), corpus analysis, for example, did not include functional attributes (e.g., nominal subject, direct object, or indirect object) as part of their corpus analysis. This is clearly an area for future research.



#### 4.2.3.2.5 Phrasal complexity discussion summary

Overall, the results indicate that higher proficiency essays include complex noun phrases. Generally, these results support Biber et al.'s (2011) corpus-based hypotheses regarding writing development. As writers become more proficient, their essays tend to be more characteristic of academic writing: They include nominals (e.g., subjects and objects) that are more complex, and in particular that have prepositional phrases as modifiers. These findings also align with the findings of research with Coh-Metrix indices *number of words before the main verb* and *modifiers per noun phrase* (Crossley & McNamara, 2014; Guo et al., 2013; McNamara et al., 2010), which found that essays with more words before the main verb (including nominal subjects) and essays that include more modifiers per noun phrase tend to earn higher scores.

The results highlighted the predictive validity of both standard deviation indices, which align with TOEFL rubric descriptors. The results also suggested that the inclusion of fine-grained indices that take into account the function of a particular nominal (e.g., subject or direct object) and type of dependent (e.g., prepositional phrases) not only provide detailed information about writing proficiency, but also lead to stronger models than indices than larger-grained indices. Based on correlation alone, the index *dependents per nominal*, for example, explained 11.0% of the variance in essay scores ( $r = .332$ ,  $R^2 = .110$ ). The full regression model, which was comprised of six fine-grained indices and did not include *dependents per nominal*, explained 20.0% of the variance.

Previous research (e.g., Cumming et al., 2005) has suggested that syntactic complexity plays but a small role in rater's judgments of writing quality. In a similar fashion as Cumming et al., this study found that traditional clause and T-unit indices explain a small percentage of the variance in essay scores. Similarly, this study found that fine-grained clausal indices explain a

small amount of the variance in essay scores. These two findings would support the notion that syntactic complexity is not a critical determiner of writing proficiency. At the phrasal level, however, a substantial amount of the variance was explained by complexity measures, suggesting that syntactic complexity indeed contributes to the construct of writing proficiency. This suggests that AES models may be enriched by the inclusion of indices related to phrasal complexity (and variation). The inclusion of such indices may not only increase model accuracy, but would also increase construct coverage. The results also suggest that academic writing classrooms may benefit from the inclusion of instruction and practice in embedding information in noun phrases.

#### **4.2.4 Research Question 4a: Syntactic sophistication**

##### ***4.2.4.1 Results: Syntactic sophistication***

Next, the potential for the 190 indices of syntactic sophistication to explain the variance in holistic scores of essay quality in TOEFL independent essays was explored. Eleven indices violated the assumption of normality and were removed from further consideration. Of the remaining 179 variables, 93 did not reach the minimum correlation threshold of  $r \geq 0.100$  and were removed from further consideration. Of the remaining 86 variables, 72 were removed due to multicollinearity. The remaining 14 variables (see Table 4.12) were entered into a 10-fold stepwise regression. The resulting model, which included seven variables, explained 15.8% ( $r = .398$ ,  $R^2 = .158$ ) of the variance in holistic essay scores (see Table 4.13 for the model). When the 10-fold model was applied to the entire dataset, it yielded a significant model ( $F(7, 472)$ ,  $p < .001$ ) that explained 18.3% ( $r = .427$ ,  $R^2 = .183$ ) of the variance. The model explained 15.2% ( $r = .391$ ,  $R^2 = .152$ ) of the variance in prompt 1 scores and 20.6% ( $r = .454$ ,  $R^2 = .206$ ) of the variance in prompt 2 scores. A Fisher's  $r$  to  $z$  transformation indicated that the amount of



variance explained by the model across the two prompts did not differ significantly ( $z = -0.84$ ,  $p = .400$ ). The exact accuracy of the scores predicted by the model was 39.2%, and the exact/adjacent accuracy was 89.6%. The reported Kappa = .232, suggests slight agreement between the actual and predicted scores (Landis & Koch, 1977).

*Table 4.12 Correlations between holistic essay score and syntactic sophistication variables entered into regression*

Variable	Correlation with Holistic Score
average delta p score verb (cue) - construction (outcome) (types only) - academic	0.251
average lemma construction frequency (types only) - all	-0.234
average faith score verb (cue) - construction (outcome) - fiction (standard deviation)	0.206
average delta p score construction (cue) - verb (outcome) - academic (standard deviation)	0.185
average construction frequency, log transformed - all	-0.171
average lemma frequency, log transformed - fiction	-0.165
collostruction ratio - all	0.160
collostruction ratio (types only) - academic	0.155
percentage of constructions in text that are in reference corpus - fiction	-0.154
collostruction ratio (types only) - magazine	0.144
average construction frequency (types only) - fiction	-0.113
average faith score construction (cue) - verb (outcome) - fiction (standard deviation)	0.112
collostruction ratio (types only) - fiction	0.108
construction type-token ratio - fiction	-0.103

*Table 4.13 Summary of syntactic sophistication multiple regression model*

Entry	Predictors included	<i>r</i>	<i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup> change	$\beta$	<i>SE</i>	<i>B</i>
1	average delta p score verb (cue) - construction (outcome) (types only) - academic	.251	.063	.063	11.419	4.737	.141
2	average delta p score construction (cue) - verb (outcome) - academic (standard deviation)	.256	.065	.003	4.214	2.918	.082
3	average delta p score construction (cue) - verb (outcome) - academic (standard deviation)	.312	.097	.032	2.784	.845	.139
4	average construction frequency, log transformed - all	.354	.125	.028	-1.085	.209	-.286
5	percentage of constructions in text that are in reference corpus - fiction	.359	.129	.004	-1.628	.770	-.099
6	collostruction ratio (types only) - magazine	.370	.137	.008	.017	.009	.086
7	construction type-token ratio - fiction	.427	.183	.046	-2.808	.545	-.271

*Note.* Estimated constant term = 11.299,  $\beta$  = unstandardized beta, *SE* = standard error; *B* = standardized beta.

#### 4.2.4.2 Discussion: Syntactic Sophistication

The relationship between indices and TOEFL writing was significant and demonstrated a medium effect. Seven variables were included in a model that explained 18.3% of the variance in essay score. Essays that included more strongly associated verb – VAC combinations (see Table 4.14 **Error! Reference source not found.**) and included less frequent VACs (see Table 4.15 **Error! Reference source not found.**) tended to earn higher scores. Additionally, essays that had a lower type-token ratio (e.g., repeated some VACs) tended to earn higher scores. The findings generally support usage-based perspectives on language learning (e.g., Behrens, 2009; Ellis, 2002a; Tomasello, 2003) in that indices related to VAC frequency and strength of association were indicators of writing development, though some important caveats are in order.

Table 4.14 Examples of weak and strong verb-VAC associations in TOEFL essays

Essay Score	Association	Verb-VAC Combination
2	weak	<p style="text-align: center;">nsubj – agree – dobj</p>
5	strong	<p style="text-align: center;">subject – require – direct object – direct object</p>

Table 4.15 Examples of high and low frequency VACs

Essay Score	Frequency	VAC
2	high	<p style="text-align: center;">nsubj – verb – dobj</p>
5	low	<p style="text-align: center;">subject – verb – direct object – direct object</p>

Research from a usage-based perspective has demonstrated that constructions that are more frequent in the input will be learned earlier/more easily (e.g., Ellis & Ferreira-Junior, 2009a; Lieven et al., 1997) than less frequent constructions. Methodologically, this study diverged from previous studies in four important ways. First, previous studies have measured the relationship between learner input and output directly, while in this study learner output is measured directly (essays) but a reference corpus was used as a proxy for input. Second, previous studies have been longitudinal, while this study used holistic writing proficiency scores. Third, previous studies have examined a small number of VACs, while this study accounts for all

of the VACs that are extant in COCA. Finally, while other developmental studies have studied oral construction development, this study studied construction development in writing. Despite these important differences, the results with regard to frequency supported previous findings that frequency is an important factor in language development (Ellis & Ferreira-Junior, 2009b; Lieven et al., 1997). The findings of the current study suggest that lower proficiency writers tend to use VACs that are more frequent in the input, and therefore are more easily learned. Higher proficiency learners, on the other hand, tend to use constructions that are less frequent in the input, which are less easily learned. This suggests from a usage-based perspective that higher proficiency learners have had more language experiences, enabling them to learn less frequently encountered constructions.

Beyond frequency, usage-based studies have also been interested in association strength. For instance, Ellis and Ferreira-Junior (2009a, 2009b) found a positive relationship between verb-VAC strength of association in the input and learner output. Learners were more likely to use verb-VAC combinations that were more strongly associated in the interlocutor input. This relationship was especially strong when delta P was used as the association measure with constructions as the cue and verbs as the outcome. Extrapolating these results, we would expect that more strongly associated verb-VAC combinations would be learned earlier/more easily, and therefore more highly proficient language users would use less strongly associated combinations (in addition to strongly associated ones). In the current study, however, the opposite trend was found. Lower scoring essays (ostensibly written by lower proficiency language users) tended to include verb-VAC combinations with lower association scores, while higher scoring essays tended to include more strongly associated combinations. While these findings are surprising in light of Ellis and Ferreira-Junior (2009a, 2009b), they are less surprising in light of other related

(but not developmental) studies. For example, Römer et al. (2014; 2015) found that advanced L2 learners had similar verb preferences as L1 speakers for the nominal subject-verb-prepositional phrase VACs that were tested, both in elicitation tasks and in corpus data. This suggests that advanced L2 speakers have had sufficient language exposure to have learned which verbs are normally used in particular constructions. The findings of this study suggest that raters may be sensitive to verb-VAC strength of association. Essays that include more strongly associated verb-VAC combinations are judged to be of higher proficiency than essays that included less strongly associated verb-VAC combinations.

One way to align the diverging findings is to suggest that syntactic development at the verb-VAC interface is not strictly linear. It has been established that, at least for a relatively small set of VACs (and at early stages of development), learners tend to learn verb-VAC combinations as fixed chunks (Eskildsen, 2009; Ninio, 1999). Through repeated language experiences with similar combinations, learners begin to discover that parts of fixed expressions (e.g., verbs) are variable. A pathbreaking verb will be used in place of the verb in the “fixed” expression, which will then be followed by the use of more verbs (Ninio, 1999). For the learners in this study, it may be that after the verb slot becomes variable, learners overgeneralize, and use verb-VAC combinations that are atypical. Through further language experiences, however, verb-VAC sensitivities are formed and more typical verb-VAC combinations are used.

These findings also have important implications for writing assessment. The results suggest that raters may be sensitive to both the relative frequency of constructions themselves and the strength of association between constructions and the verbs that fill them. This may be captured in the TOEFL independent writing rubric wherein verb-VAC combinations may be subsumed under the descriptor “appropriate word choice”. Essays that include weakly associated

verb-VAC combinations earn lower scores, while essays that include strongly associated verb-VAC combinations tend to earn higher scores. It may be useful to make this connection explicit both to raters (to help reduce rater variability) and to test-takers (to explicitly outline rater expectations), though the efficacy of both of these suggestions should be empirically investigated. AES models could also benefit from the inclusion of indices of syntactic sophistication. The inclusion of such indices could both increase model accuracy and construct coverage.

Links between writing success and verb-VAC combinations suggest that it may be valuable to include verb-VAC combination instruction in language learning classrooms in general, and writing classrooms in particular. Such instruction could be both implicit and explicit (Littlemore, 2009). Implicit instruction could involve the inclusion of materials that are sensitive to verb-VAC strength of association profiles by ensuring that a high percentage of verb-VAC combinations were strongly associated. The inclusion of such materials may facilitate the tuning of learners verb-VAC combination sensitivities. Other instructional techniques could include teaching VACs explicitly, not unlike vocabulary items are often taught. Such instruction would include both form-meaning mappings and VAC verb profiles.

#### **4.2.5 Research Question 5a: Combined syntactic complexity and sophistication**

##### ***4.2.5.1 Results: Combined syntactic complexity and sophistication***

Finally, the potential for the 40 syntactic complexity and sophistication variables entered into each previous regression model to explain the variance in holistic scores of essay quality in TOEFL independent essays was explored. All of these variables met the criteria for normality and minimum correlation with holistic score. No variables were multicollinear. Forty variables (see Table 4.16) were entered into a 10-fold stepwise regression. The initial model included three

variables with switched signs. These were removed, and the regression was run again. The second model included one variable with switched signs, which was removed and the regression was run a third time. The resulting model included six phrasal complexity indices, five indices of syntactic sophistication, two clausal complexity indices, and no SCA variables. This 13-variable model explained 29.7% ( $r = .545$ ,  $R^2 = .297$ ) of the variance in holistic essay scores (see Table 4.17 for the model). When the 10-fold model was applied to the entire dataset, it yielded a significant model ( $F(13, 466)$ ,  $p < .001$ ) that explained 34.2% ( $r = .584$ ,  $R^2 = .342$ ) of the variance. The model explained 26.4% ( $r = .514$ ,  $R^2 = .264$ ) of the variance in prompt 1 scores and 41.2% ( $r = .642$ ,  $R^2 = .412$ ) of the variance in prompt 2 scores. A Fisher's  $r$  to  $z$  transformation indicated that the amount of variance explained by the model across the two prompts differed significantly ( $z = -2.11$ ,  $p = .035$ ). The exact accuracy of the scores predicted by the model was 45.8%, and the exact/adjacent accuracy was 92.7%. The reported quadratic weighted Kappa = .416, suggests moderate agreement between the actual and predicted scores (Landis & Koch, 1977).

*Table 4.16 Correlations between holistic essay score and variables entered into regression*

Variable	Category	<i>r</i>
dependents per nominal	Phrasal Cx	0.332
dependents per object of the preposition (no pronouns)	Phrasal Cx	0.290
prepositions per nominal (no pronouns)	Phrasal Cx	0.288
prepositions per object of the preposition	Phrasal Cx	0.287
dependents per nominal (standard deviation)	Phrasal Cx	0.277
dependents per object of the preposition	Phrasal Cx	0.267
adjectival modifiers per object of the preposition	Phrasal Cx	0.265
dependents per direct object (standard deviation)	Phrasal Cx	0.259
average delta p score verb (cue) - construction (outcome) (types only) - academic	Sophistication	0.251
mean length of clause	SCA	0.240
dependents per object of the preposition (no pronouns, standard deviation)	Phrasal Cx	0.239
average lemma construction frequency (types only) - all	Sophistication	-0.234
dependents per nominal subject (standard deviation)	Phrasal Cx	0.230
dependents per direct object (no pronouns)	Phrasal Cx	0.226
average faith score verb (cue) - construction (outcome) - fiction (standard deviation)	Sophistication	0.206
determiners per nominal subject	Phrasal Cx	0.203
coordinate phrases per clause	SCA	0.190
average delta p score construction (cue) - verb (outcome) - academic (standard deviation)	Sophistication	0.185
nominal subjects per clause	Phrasal Cx	-0.172
average construction frequency, log transformed - all	Sophistication	-0.171
average lemma frequency, log transformed - fiction	Sophistication	-0.165
collostruction ratio - all	Sophistication	0.160
determiners per nominal (no pronouns)	Phrasal Cx	0.157
collostruction ratio (types only) - academic	Sophistication	0.155
percentage of constructions in text that are in reference corpus - fiction	Sophistication	-0.154
dependents per direct object	Phrasal Cx	-0.154
adjectival modifiers per direct object (no pronouns)	Phrasal Cx	0.146
collostruction ratio (types only) - magazine	Sophistication	0.144
prepositions per clause	Clausal Cx	0.141
direct objects per clause	Clausal Cx	-0.137
dependents per clause (standard deviation)	Clausal Cx	0.128
complex nominals per T-unit	SCA	0.124
adverbial modifiers per clause	Sophistication	0.116
determiners per direct object (no pronouns)	Phrasal Cx	0.116
average construction frequency (types only) - fiction	Sophistication	-0.113
average faith score construction (cue) - verb (outcome) - fiction (standard deviation)	Sophistication	0.112
prepositions per direct object	Phrasal Cx	0.110
collostruction ratio (types only) - fiction	Sophistication	0.108



clausal complements per clause	Sophistication	-0.106
construction type-token ratio - fiction	Sophistication	-0.103

*Table 4.17 Summary of multiple regression model*

Entry	Predictors included	Category	<i>r</i>	<i>R</i> <sup>2</sup>	<i>R</i> <sup>2</sup> change	$\beta$	<i>SE</i>	<i>B</i>
1	dependents per nominal	Phrasal Cx	.332	.110	.110	.407	.297	.087
2	dependents per object of the preposition (no pronouns)	Phrasal Cx	.354	.125	.015	.614	.194	.150
3	prepositions per nominal (no pronouns)	Phrasal Cx	.371	.138	.012	1.639	.780	.104
4	dependents per nominal (standard deviation)	Phrasal Cx	.379	.144	.006	.450	.349	.071
5	dependents per direct object (standard deviation)	Phrasal Cx	.407	.165	.022	.674	.177	.171
6	average faith score verb (cue) - construction (outcome) - fiction (standard deviation)	Sophistication	.444	.198	.032	6.677	2.01 1	.130
7	average delta p score construction (cue) - verb (outcome) - academic (standard deviation)	Sophistication	.463	.215	.017	2.204	.791	.110
8	average construction frequency, log transformed - all	Sophistication	.479	.230	.015	-.931	.197	-.246
9	dependents per direct object	Phrasal Cx	.491	.241	.011	-.343	.114	-.135
10	collostruction ratio (types only) - magazine	Sophistication	.505	.255	.015	.021	.008	.104
11	adverbial modifiers per clause	Clausal Cx	.511	.261	.006	.775	.404	.079
12	clausal complements per clause	Clausal Cx	.515	.265	.004	-.633	.631	-.040
13	construction type-token ratio - fiction	Sophistication	.584	.342	.076	-3.698	.503	-.356

*Note.* Estimated constant term = 7.793,  $\beta$  = unstandardized beta, *SE* = standard error; *B* = standardized beta.

Table 4.18 includes an overview of the results for each model with regard to correlation with holistic score, exact matches between predicted and actual scores, and exact or adjacent matches between predicted and actual scores.

*Table 4.18 An overview of the performance of each model tested*

	Correlation with Holistic Score	Prediction Accuracy (Exact)	Prediction Accuracy (Exact and Adjacent)
SCA	.240	37.3%	87.9%
Clausal	.254	40.2%	86.9%
Phrasal	.447	42.9%	92.5%
Sophistication	.427	39.2%	89.6%
Combined	.584	45.8%	92.7%

A series of Fisher  $r$  to  $z$  transformation tests were conducted to determine whether the differences between models were due to chance. The results of these tests indicate that a number of significant differences existed between the models. All models except for the fine-grained clausal complexity model were significantly stronger than the SCA model. The phrasal, sophistication, and combined models were also significantly stronger than the fine-grained clausal complexity model. Additionally, the combined model was stronger than any of the other models. See Table 4.19 for a summary of these results.

*Table 4.19 A comparison of models using Fisher's  $r$  to  $z$  transformation*

	SCA	Clausal Cx	Phrasal Cx	Sophistication
SCA				
Clausal Cx	$p = .818$			
Phrasal Cx	$p < .001$	$p < .001$		
Sophistication	$p = .001$	$p = .002$	$p = .704$	
Combined	$p < .001$	$p < .001$	$p = .004$	$p = .001$

A series of McNemar tests were conducted to determine whether the exact match accuracies of the models differed significantly. The results of these tests indicate that a few significant differences existed between the models. The fine-grained phrasal model and the combined model demonstrated significantly more exact matches than the SCA model. Additionally, the combined model demonstrated significantly more exact matches than the clausal complexity model and the sophistication model. See Table 4.20 for a summary of the exact accuracy results.

*Table 4.20 A comparison of the exact accuracy of the models using McNemar's test*

	SCA	Clausal Cx	Phrasal Cx	Sophistication
SCA				
Clausal Cx	$p = .202$			
Phrasal Cx	$p = .006$	$p = .267$		
Sophistication	$p = .481$	$p = .742$	$p = .165$	
Combined	$p < .001$	$p = .033$	$p = .198$	$p = .005$

A series of McNemar tests were also conducted to determine whether the exact/adjacent match accuracies of the models differed significantly. The results of these tests indicate that a few significant differences existed between the models. The phrasal model and the combined model both demonstrated significantly more exact/adjacent matches than the SCA and clausal complexity models. Additionally, the combined model outperformed the sophistication model. See Table 4.21 for a summary of the exact/adjacent accuracy results.

*Table 4.21 A comparison of the exact/adjacent accuracy of the models using McNemar's test*

	SCA	Clausal Cx	Phrasal Cx	Sophistication
SCA				
Clausal Cx	$p = .522$			
Phrasal Cx	$p = .001$	$p < .001$		
Sophistication	$p = .332$	$p = .117$	$p = .070$	
Combined	$p < .001$	$p < .001$	$p = 1.000$	$p = .008$

#### **4.2.5.2 Discussion: Combined indices of syntactic complexity and sophistication**

To investigate the relationship between large grained clausal indices of complexity, fine grained indices of clausal and phrasal complexity, and indices of syntactic sophistication, 40 previously identified indices were entered into a stepwise multiple regression to predict TOEFL writing scores. The resulting model, which explained 34.2% of the variance in essay scores included eleven indices. Indices from each index category were included in the final model, with the exception of the traditional SCA indices.

The results suggest that fine-grained nominal complexity is an important aspect of TOEFL writing quality, followed by syntactic sophistication, and fine-grained indices of clausal

complexity (no traditional indices were included in the final model). In the combined model, fine-grained nominal complexity indices explained 17.6% of the variance, indices of syntactic sophistication explained 15.5% of the variance, and clausal complexity indices explained 1.0% of the variance in essay scores. This generally follows the trends observed in the individual studies wherein indices of fine grained phrasal complexity indices and indices of syntactic sophistication were much stronger predictors of holistic essay scores than either traditional indices of syntactic complexity or fine-grained indices of clausal complexity. Generally, these results support Biber et al.'s 2011 claims regarding the importance of clausal versus phrasal elaboration in academic writing. These results also support the extension of usage-based perspectives on language development to writing development and assessment. Individually, indices of syntactic sophistication demonstrated meaningful but small correlations with holistic score. These correlations tended to be stronger than their complexity counterparts (i.e., dependents per clause). Furthermore, writing quality predictor models consisting of syntactic sophistication indices and phrasal complexity indices, respectively, were significantly stronger than models consisting of traditional indices. This suggests that high proficiency writers are characterized by their command of a number of features of phrasal complexity (e.g., embedding of prepositional phrases), which also leads to the production of a wider range of phrasal complexity features. This also suggests that high proficiency writers are also characterized by their use of less frequent VACs and verb-VAC combinations that are strongly associated.

### **4.3 Summary**

Overall, the results of this study have particularly important implications for second language acquisition, second language writing, and second language assessment. Most SLA and L2 writing studies that investigate syntactic development have operationalized the construct

using indices such as mean length of clause and mean length of T-unit (Lu, 2010, 2011; Ortega, 2003; Wolfe-Quintero et al., 1998). The relationship between these indices and syntactic development (broadly defined) has been rather weak and at times contradictory. The investigation of traditional indices in this chapter followed this trend with results that were significant but with a small effect size and slight agreement between actual and predicted scores. In this study, only a single index related to syntactic complexity, mean length of clause, which demonstrated a small, positive relationship with holistic essay scores was included in the predictor model.

The newly developed fine-grained indices of phrasal complexity and indices of sophistication, however, contributed to predictor models that demonstrated moderate effect sizes. Furthermore, the results from the traditional indices of syntactic complexity study provide very little information regarding the nature of syntactic development (i.e., write longer clauses). The fine-grained complexity indices and indices of syntactic sophistication, on the other hand, provide much more detailed information. With regard to clausal structure, more proficient writers tend to include more direct dependents, and also a wider range of dependents. In particular, more proficient writers tend to include more non-finite clauses, more adverbials, and more adverbial prepositions than less proficient writers. More proficient writers also use more complex and varied phrases, and in particular include more prepositional phrases and adjectival modifiers. The results in regard to syntactic sophistication are slightly more opaque, but suggest that more proficient writers use less frequent verb argument construction combinations, and verb-VAC combinations that are more strongly associated (and have a wider range of association scores) than less proficient writers.

#### 4.4 Limitations and future directions

Exact and adjacent matches were reported for each study, along with quadratic weighted Kappa statistics, following related work in automatic essay scoring (AES; e.g., Attali & Burstein, 2006). The agreement between scores predicted by models including indices of syntactic development and actual scores ranges from slight to fair. Exact and adjacent matches also failed to reach state of the art levels of 55% adjacent and 98% exact agreement (Attali & Burstein, 2006; Crossley, Kyle, Allen, Guo, & McNamara, 2014). This demonstrates the multi-faceted nature of writing assessment, and is not surprising given that most (if not all) essay scoring rubrics include descriptors from a range of different language proficiency areas (e.g., lexical proficiency, cohesion, etc.) in addition to syntax. Accordingly, state of the art AES systems include a variety of index types in their models. Future work in this area should explore the degree to which fine-grained indices of syntactic complexity and sophistication can add to the accuracy (and construct coverage) of AES systems. Future research should also address the relationship between prompt and syntax. Across syntactic development index types, prompt 2 consistently demonstrated a larger effect between syntactic features and essay score. These differences reached significance in two of the five studies (the syntactic sophistication study and the combined study).

A potential limitation for the sophistication indices is the use of COCA as a proxy for L2 language experience. COCA was designed to be representative of general English language use in America (Davies, 2009, 2010), but likely does not fully represent the types of language exposure that L2 learners are exposed to. A corpus that included the types of language that language learners are commonly exposed to would likely serve as a better proxy for language experience, and may yield stronger (and more representative) results. Outlining the

characteristics for such a corpus, collecting appropriate texts, and replicating the studies in this dissertation may be rich areas of investigation. A starting point for such a task may be to create an L2 version of the Touchstone Applied Science Associates (TASA) corpus (Landauer, Foltz, & Laham, 1998), which includes the types of written texts (e.g., textbooks) public school students in the United States are likely to encounter. An L2 version of the TASA corpus could include a number of popular second language textbook series, including extensive reading texts. A second step might be to create an L2 language classroom version of a corpus such as the Michigan Corpus of Academic Spoken English (MICASE) (Simpson-Vlach & Leicher, 2006), with a related third step of developing accurate methods of parsing (transcribed) spoken data.

One area of particular interest for future work in syntactic development beyond replicating and expanding on the studies in this chapter and in Chapter 5 is the investigation of phrasal sophistication. Clausal indices of syntactic sophistication demonstrated a stronger relationship with essay score than clausal complexity indices. Considering that phrasal sophistication indices were generally stronger than clausal complexity indices, the area of phrasal sophistication may yield even stronger results. In this chapter, indices of syntactic complexity and sophistication were used to model holistic essay scores. Future research should focus on using these indices to model analytic syntactic development scores, which may help to avoid some of the measurement error associated with holistic scores.

#### **4.5 Conclusion**

This chapter has tested and validated the newly developed indices of fine-grained clausal and phrasal complexity and clausal sophistication. The newly developed TAASSC indices outperform traditional indices of syntactic complexity such as mean length of clause in explaining the variance in TOEFL independent essay scores. In addition to validating fine-

grained complexity indices and indices of syntactic sophistication, this study suggests that syntactic variation (as measured using standard deviations) are useful indicators of writing proficiency.

## 5 LONGITUDINAL SYNTACTIC DEVELOPMENT

Syntactic development has been of interest to the field of L2 writing (and SLA) for over 45 years. Much of the research in this area has focused on a small number of relatively large-grained indices (e.g., mean length of clause, mean length of T-unit). The results, however, have been mixed (e.g., Ortega, 2003; Wolfe-Quintero et al., 1998), resulting in a lack of consensus regarding how L2 syntax develops. Additionally, most syntactic development studies have adopted cross-sectional designs (e.g., Lu, 2011), and most longitudinal studies have tracked development over a relatively short period of time (e.g., one semester; Crossley & McNamara, 2014; c.f., Knoch et al., 2014). This chapter re-examines L2 syntactic development using both established indices of syntactic complexity and newly developed, fine-grained indices of syntactic complexity and sophistication, which are implemented in the freely available Tool for the Automatic Analysis of Syntactic Sophistication and Complexity (TAASSC). Specifically, longitudinal development is measured with regard to two student populations who differ with regard to age, context, time of data collection, and writing genre. Furthermore, this study examines syntactic development over a relatively long period of time (1-2 years). Traditional large-grained (e.g., mean length of clause) indices of syntactic complexity, in addition to newly developed fine-grained clausal and phrasal indices of syntactic complexity and frequency-based indices of syntactic sophistication are used to determine how L2 syntax develops over time.

This chapter is guided by research questions 1b-5b:



- 1b. What is the relationship between the Syntactic Complexity Analyzer indices and longitudinal writing development?
- 2b. What is the relationship between fine-grained indices of clausal complexity and longitudinal writing development?
- 3b. What is the relationship between fine-grained indices of phrasal complexity and longitudinal writing development?
- 4b. What is the relationship between usage-based indices of syntactic sophistication and longitudinal writing development?
- 5b. What is the relationship between all syntactic development indices included in TAASSC and longitudinal writing development?

## **5.1 Method**

### **5.1.1 Indices**

For this analysis, two sets of indices were used. First, to address research question 1b, indices included in the syntactic complexity analyzer, which represents syntactic complexity indices commonly used in L2 writing research (e.g., mean length of T-unit) were used to measure syntactic development (see Chapter 3 for an in-depth treatment of these indices). To address research questions 2b-5b, the nine component scores included in TAASSC were used (see Chapter 3 for an in-depth description of these components).

### **5.1.2 Learner corpora**

Two small longitudinal learner corpora were used to analyze the relationship between indices of syntactic development and writing development with regard to time spent studying English. The use of longitudinal corpora in this chapter complements the use of a larger cross-

sectional corpus in Chapter 4. Cross-sectional learner corpora allow for the analysis of a relatively large number of texts that represent a wide range of proficiency levels, which may increase the generalizability of the results. Longitudinal corpora tend to be smaller due to factors such as attrition (Mackey & Gass, 2005), but allow one to control for the random effects introduced by individual differences between writers. In a longitudinal corpus, such effects become fixed because individual variability can be accounted for (since we have multiple samples from the same individuals; Winter, 2013). Each learner corpus used is described below.

### 5.1.2.1 *Salsbury written corpus*

The Salsbury written corpus (Salsbury, 2000) consists of 337 unstructured, untimed free writes (totaling 63,700 words) written by 6 L2 English language learners enrolled in an Intensive English Program at an American university. The free writes were collected over the course of one year. Free writes were collected from the participants every one to two weeks, and the average length of time between the first and last collected texts is 49.33 weeks. Of the six participants, three were L1 Arabic users, one was an L1 Spanish user, one was an L1 Japanese user, and the remaining participant was an L1 Korean user. Participants chose to write on a number of topics over the course of the year, ranging from descriptions of their daily life to argumentative treatments of controversial issues. See Table 5.1 for an overview of this corpus.

*Table 5.1 Overview of Salsbury written corpus data*

Name	L1	Gender	Number of Texts Collected	Weeks Between First and Last Text	Number of Words Collected	Average Number of Words per Text
EunHui	Korean	Female	89	50	13,072	146.88
Faisal	Arabic	Male	39	49	6,305	161.67
Jalil	Arabic	Female	43	47	10,400	241.86
Kamal	Arabic	Male	26	50	4,389	168.81
Marta	Spanish	Female	53	50	11,574	218.38
Takako	Japanese	Female	87	50	17,960	206.44

Institutional TOEFL examinations were administered every two months during the collection period. The entire cohort of six participants were present for four of the administrations of the TOEFL. A repeated measures ANOVA indicated that a significant positive linear relationship existed between time and TOEFL scores ( $p = .001, \eta^2_p = .889$ ).

Figure 5.1 includes an overview of the TOEFL data.

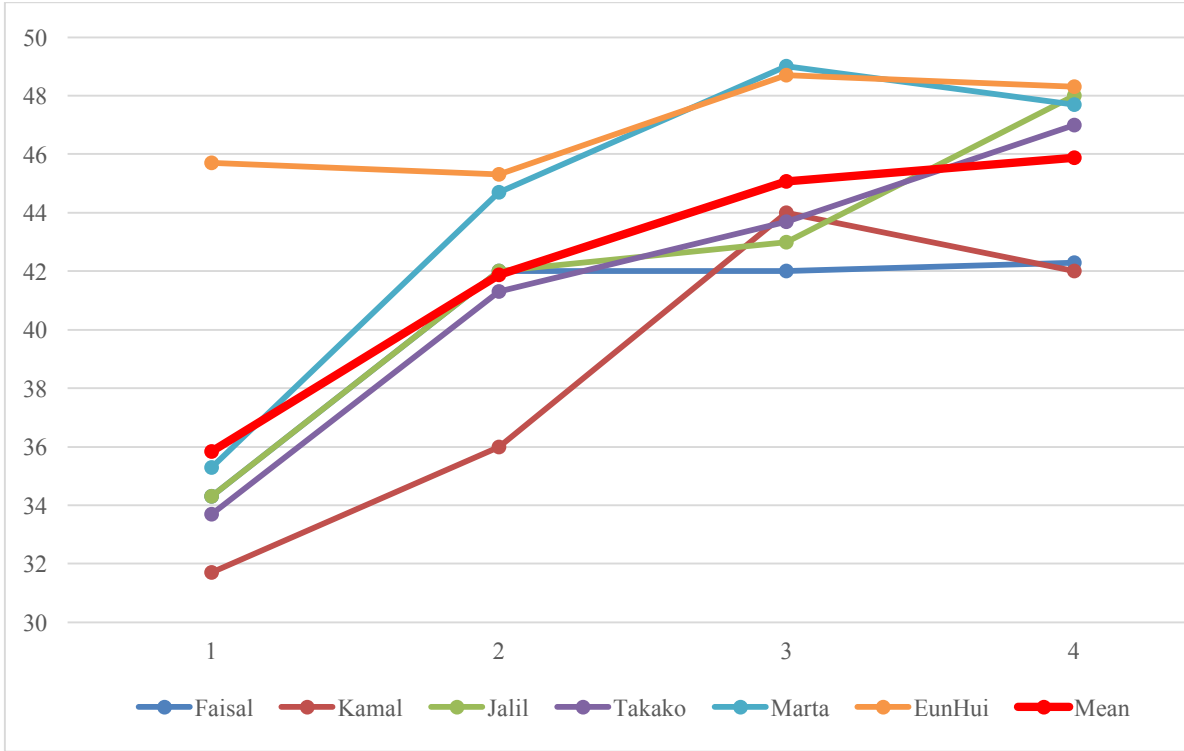


Figure 5.1 Increase in TOEFL scores over time (Salsbury)

For the purposes of this chapter, a subcorpus was created. The subcorpus was comprised of ten weeks in which each participant submitted at least one free write. During the fall semester (Weeks 1-15), collection points were 3 weeks apart. During the spring and summer semesters collection points ranged from 5-7 weeks apart. All free writes from a particular participant for each week were included as a single .txt file. In two cases, free writes from an adjacent week were used. Faisal’s free writes from week 2 were counted as week 3 and his free writes from

week 44 were counted as week 43. An average of 4,383 words were collected each week, and in total 26,298 words were collected. See Table 5.2 for a summary of this data.

*Table 5.2 Number of words collected per participant in Salisbury subcorpus*

Time	Week	EunHui	Faisal	Jalil	Kamal	Marta	Takako
1	3	442	401	326	118	328	290
2	6	143	291	193	201	205	354
3	9	643	280	544	143	506	566
4	12	529	801	588	101	266	525
5	15	176	846	1022	257	300	513
6	21	461	440	540	157	746	1300
7	26	281	586	374	232	492	230
8	34	259	293	519	305	260	263
9	43	288	141	510	355	412	2202
10	50	258	1114	488	342	268	284
<b>Total</b>		<b>3480</b>	<b>5193</b>	<b>5104</b>	<b>2211</b>	<b>3783</b>	<b>6527</b>

#### *5.1.2.2 Verspoor longitudinal corpus*

The Verspoor longitudinal corpus (Verspoor et al., 2012) includes essays written by nine Dutch students at a competitive secondary school in the Netherlands over two years. Essays were collected three times per year, for a total of six essays per student. Essays were completed using a computer and were untimed, but limited to 1000 characters. All participants wrote on the same topic for a particular collection point, but were novel at each collection point. Each prompt was designed in a manner that avoided the need for specialized language. See Table 5.3 for a list of the topics used.

*Table 5.3 Essay topics in the Verspoor longitudinal corpus*

Essay	Prompt
1	Write a short story about your new school, friends and teachers.
2	Pretend you have a foreign pen-pal. Tell him/her about your favorite holiday and explain what you find so special about it.
3	Write about the most awful (or best) thing that happened to you at school so far. It does not have to be truthful.
4	Write a short story about the most awful (or best) thing that happened to you during summer vacation. It does not have to be truthful.
5	Pretend you have just won 1000 euros. Write a short story about what you would do with the money.
6	Pretend your school principal has stated that from now on anyone should wear a school uniform. Write him/her a short letter to explain why you agree/do not agree with this new rule.

Each essay was also assigned a holistic proficiency score, which ranged from 0-7. Raters included 8 experienced ESL teachers. Raters were split into two groups, who evaluated essays based on a holistic rubric created iteratively for the dataset. If three of four raters agreed on a particular score, the score was kept. The score for any essay that did not receive the same score from three of the four raters was then adjudicated by the raters until sufficient agreement was reached (Verspoor et al., 2012). Table 5.4 includes an overview of the essays included in the Verspoor longitudinal corpus.

*Table 5.4 Overview of Verspoor longitudinal corpus data*

Participant	Gender	Average Score	Number of Words Collected	Average number of words
Anneke	Female	3.833	1030	171.667
Aart	Male	4.500	1057	176.167
Betje	Female	4.333	1239	206.500
Corrie	Female	4.167	1257	209.500
Drika	Female	4.000	1001	166.833
Elke	Female	4.000	974	162.333
Fenna	Female	4.167	1087	181.167
Gertruida	Female	4.333	966	161.000
Braam	Male	3.833	1202	200.333
<b>Average</b>	<b>N/A</b>	<b>4.130</b>	<b>1090.333</b>	<b>181.722</b>

A repeated measures analysis of variance (RM ANOVA) indicated a significant positive linear relationship between time and holistic essay scores ( $p < .001$ ,  $\eta^2_p = .823$ ). This indicates that the participants' writing proficiency increased over the two-year time period. Figure 5.2 includes an overview of this data.

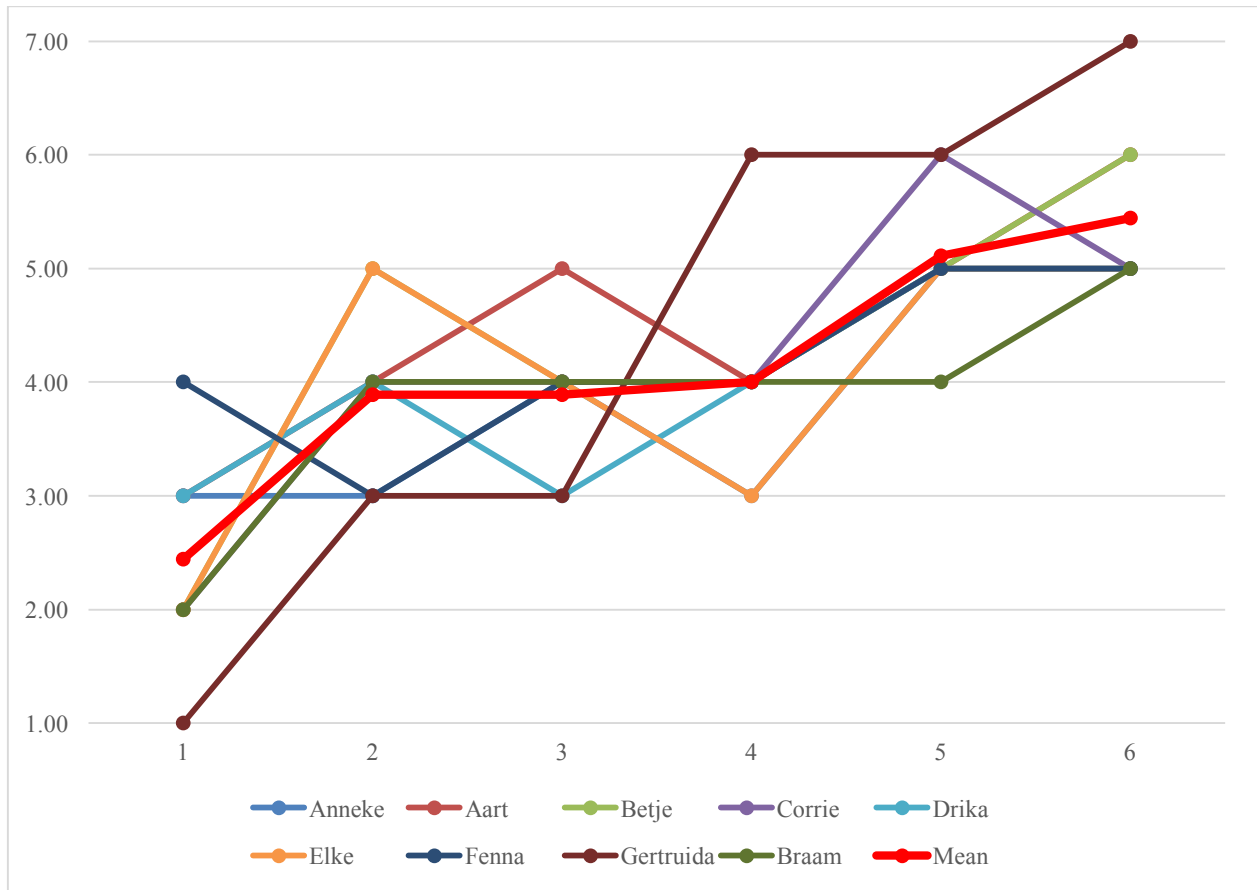


Figure 5.2 Increase in holistic scores over time in Verspoor longitudinal corpus

### 5.1.3 Statistical analyses

In order to determine whether linear development occurred over time with regard to the syntactic variables of interest, repeated measure analysis of variance (RM ANOVA) statistics were performed. Normality of the data was first checked, and any indices that violated this assumption were removed from the analysis. In most cases, this occurred due to extremely skewed data. Second, the variables of interest were checked for multicollinearity to ensure that

only unique variables were being considered. The remaining variables were entered into a RM ANOVA.

## **5.2 Results and Discussion**

### **5.2.1 Research Question 1b results: Syntactic Complexity Analyzer**

#### ***5.2.1.1 Salisbury corpus results: Syntactic Complexity Analyzer***

Eight of the 14 SCA indices met the assumption of approximate normality. Two groups of indices demonstrated strong collinearity. The first group included mean length of T-unit (MLT), mean length of sentence (MLS), clauses per T-unit (C/T) and dependent clauses per clause (DP/C). The second group included coordinate phrases per clause (CP/C) and coordinate phrases per T-unit (CP/T). MLT was selected from the first group in order to maximize comparisons with other studies, while CP/C was selected from the second group in order to permit clear comparisons with complex nominals per clause (CN/C). See Table 5.5 for descriptive statistics for the selected indices.

*Table 5.5 Salisbury corpus: Mean (standard deviation) for selected SCA indices at each collection point*

Index	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Mean length of T-unit	9.857 (2.171)	11.251 (2.853)	10.324 (2.993)	12.090 (4.079)	13.927 (5.468)	12.440 (3.892)	13.574 (3.231)	14.054 (2.730)	13.512 (3.204)	15.888 (3.065)
T-units per sentence	1.098 (0.131)	1.096 (0.106)	1.111 (0.048)	1.082 (0.141)	1.043 (0.084)	1.248 (0.253)	1.194 (0.214)	1.187 (0.184)	1.167 (0.103)	1.121 (0.069)
Complex nominals per clause	0.611 (0.169)	0.659 (0.197)	0.541 (0.151)	0.687 (0.205)	0.657 (0.223)	0.543 (0.146)	0.703 (0.135)	0.628 (0.092)	0.852 (0.409)	0.785 (0.206)
Coordinate phrases per clause	0.143 (0.074)	0.157 (0.079)	0.197 (0.075)	0.148 (0.069)	0.169 (0.122)	0.164 (0.079)	0.130 (0.076)	0.166 (0.076)	0.142 (0.059)	0.143 (0.091)



Repeated measures analysis of variance (RM ANOVA) statistics were then conducted using the four selected indices (MLT, T/S, CP/C, and CN\_C). The results indicate a positive, significant linear relationship between time and two indices: MLT ( $p < .001$ ,  $\eta^2_p = .960$ ) and T/S ( $p = .023$ ,  $\eta^2_p = .676$ ). The results also indicated that a positive (but non-significant) linear relationship was observed between time and CN/C ( $p = .078$ ,  $\eta^2_p = .495$ ). No significant linear relationship was observed between time and CP/C ( $p = .301$ ,  $\eta^2_p = .057$ ). The effects for MLT, T/S, and CN/C were large, while the effect for CP/C was small. See Table 5.6 for a summary of the data.

*Table 5.6 Repeated measure analysis of variance results for SCA variables*

Index	F	p	$\eta^2_p$
Mean length of T-unit	118.826	< .001	.960
T-units per sentence	10.455	.023	.676
Complex nominals per clause	4.905	.078	.495
Coordinate phrases per clause	.301	.607	.057

### ***5.2.1.2 Verspoor corpus results: Syntactic Complexity Analyzer***

Ten of the 14 SCA indices met the assumption of approximate normality.

Multicollinearity was an issue in this data set as well. Four, non-collinear indices emerged from the analysis (mean length of T-unit, mean length of clause, clauses per sentence, and complex nominals per sentence). See Table 5.7 for descriptive statistics for the selected indices.

*Table 5.7 Verspoor corpus: Mean (standard deviation) for selected SCA indices at each collection point*

Index	T1	T2	T3	T4	T5	T6
Mean length of T-unit	9.697 (2.043)	10.364 (1.654)	11.474 (3.779)	11.404 (2.719)	13.321 (2.556)	12.843 (1.811)
Mean length of clause	7.023 (1.954)	7.012 (0.488)	6.435 (0.531)	6.913 (1.020)	7.944 (1.346)	6.936 (0.909)
clauses per sentence	1.968 (1.311)	1.726 (0.324)	2.358 (0.938)	2.207 (0.595)	2.055 (0.620)	2.154 (0.357)
complex nominals per clause	0.489 (0.109)	0.483 (0.186)	0.480 (0.158)	0.413 (0.099)	0.523 (0.113)	0.548 (0.173)

Repeated measures analysis of variance (RM ANOVA) statistics were then conducted using these four indices. The results indicated that a significant positive linear relationship existed between time and the mean length of T-unit ( $p = .005$ ,  $\eta^2_p = .640$ ). See Table 5.8 for a summary of the results.

*Table 5.8 Repeated measure analysis of variance results for SCA variables*

Index	F	$p$	$\eta^2_p$
Mean length of T-unit	14.199	.005**	.640
Mean length of clause	.757	.410	.086
clauses per sentence	.727	.419	.083
complex nominals per sentence	.620	.454	.072

*Note.* \* indicates  $p < .05$ , \*\* indicates  $p < .01$

## 5.2.2 Research Question 1b discussion: Syntactic Complexity Analyzer

Between the two studies conducted, linear relationships were found between time and two SCA variables. Each index of syntactic development is discussed below.

### 5.2.2.1 Mean length of T-unit

A positive, linear relationship between time spent studying English as a second/foreign language and mean length of T-unit was found in both the Salsbury written longitudinal corpus ( $p < .001$ ,  $\eta^2_p = .960$ ) and the Verspoor longitudinal corpus ( $p = .005$ ,  $\eta^2_p = .640$ ). Over a one-year period, the ESL students in the Salsbury corpus on average made gains of six words per T-unit (from 9.857 to 15.888). During week 3 (the first collection point) for example, Jalil averaged 10.866 words per T-unit. As can be seen in the examples in Table 5.9, her T-units are not uniform, and include both relatively short and relatively long T-units. By week 50 (the final collection point), Jalil averages 16.828 words per T-unit. T-unit length still varies, but very short T-units are much less common.

*Table 5.9 Examples from the Salisbury corpus: Mean length of T-unit*

Collection point	Example	Length of T-unit
T1 (Week 3)	<i>In this weekend I am very happy because I am going out of the Indiana with my friend Kevin.</i>	19
	<i>He is an American friends.</i>	5
	<i>He is a nice boy to speak.</i>	6
		<b>Mean = 10</b>
T10 (Week 50)	<i>The man kind always imagine what he would like to do or where he will visit in the future.</i>	19
	<i>Some body thinking about his plan for job in future.</i>	10
		<b>Mean = 15</b>

*Note.* Examples at each collection point represent contiguous sentences.

The EFL students in the Verspoor corpus on average made gains of three words per T-unit (from 9.697 to 12.843) over a two-year period. For example, Anneke wrote an average of 8.833 words per T-unit at the beginning of the first year, but by the end of the second year wrote an average of 12.933 words per T-unit for a gain of 4 words per T-unit. Table 5.10 includes examples of the types of T-units written by Anneke at the first and last collection points. Anneke uses both relatively short and relatively long T-units in her writing both at the beginning of the study and at the end. At the first collection point, Anneke wrote a number of relatively short T-units that were comprised of simple sentences or clauses in compound sentences with few modifiers (e.g., *I often buy toast.*), but also wrote longer T-units with more modifiers (e.g., *I don't like lessons of biology and geography*). By the end of the second year of study, she is using more modifiers and complex verb phrases, which results in longer T-units.

*Table 5.10 Examples from the Verspoor corpus: Mean length of T-unit*

Collection point	Example	Length of T-unit
T1	<i>I don't like lessons of biology and geography.</i>	8
	<i>With gymnastics we go to a other gym hall</i>	9
	<i>[and] in the winter it's cold to go cycle to there.</i>	10
	<i>In the break you can buy candy or bread.</i>	9
	<i>I often buy a toast.</i>	5
	<b>Mean = 8.2</b>	
T6	<i>I think some people won't be happy after a while, and maybe feel down.</i>	14
	<i>They think the uniforms look nicer when other people wear it</i>	11
	<i>[and] they can't let other people see how they really are.</i>	10
	<b>Mean = 11.7</b>	

*Note.* Examples at each collection point represent contiguous sentences.

On average, students in both corpora increased the length of their T-units in a relatively linear fashion, though peaks and valleys existed. This general trend held true among a number of students in each study, but some students did not follow this pattern. Figure 5.3 comprises a line graph with the average mean length of T-unit score at each collection point in the Salisbury corpus plotted with each student's score. This demonstrates that although some students (such as EunHui and Takako) developed in a relatively consistent manner, others (such as Kamal and Marta) did not. Marta, for example, made a steady rise to her highest score for mean length of T-unit (23.077) at collection point five (week 15), but then also made a steady decline, and finished at 15.764 words per T-unit. Figure 5.4, which provides the average mean length of T-unit score plotted with actual scores for each student in the Verspoor corpus shows a similar pattern. Drika and Lysanne, for example, follow a relatively linear trend. Other students, such as Gertruida and Braam, however, peak at collection point three, but end with an average of four words fewer per T-unit by the final collection point. This suggests that the syntactic development with regard to T-unit length use is not strictly linear.

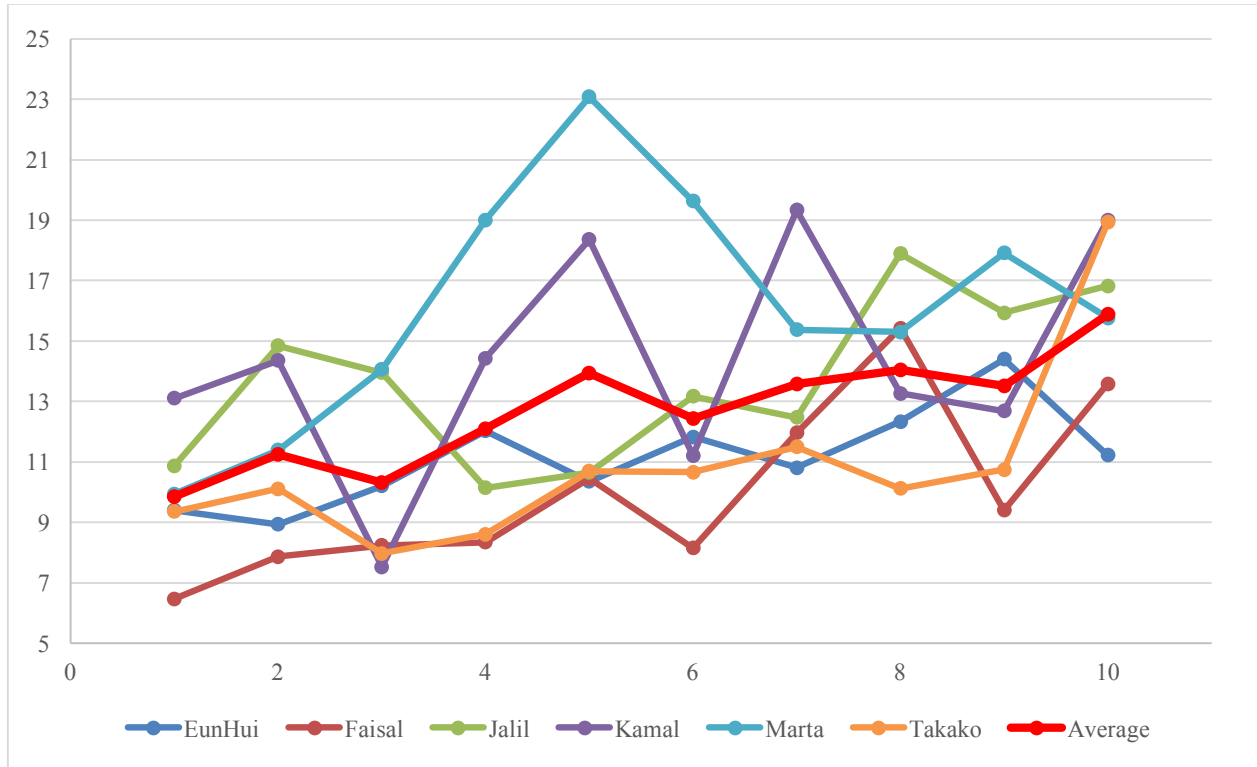


Figure 5.3 MLTU (Salsbury)

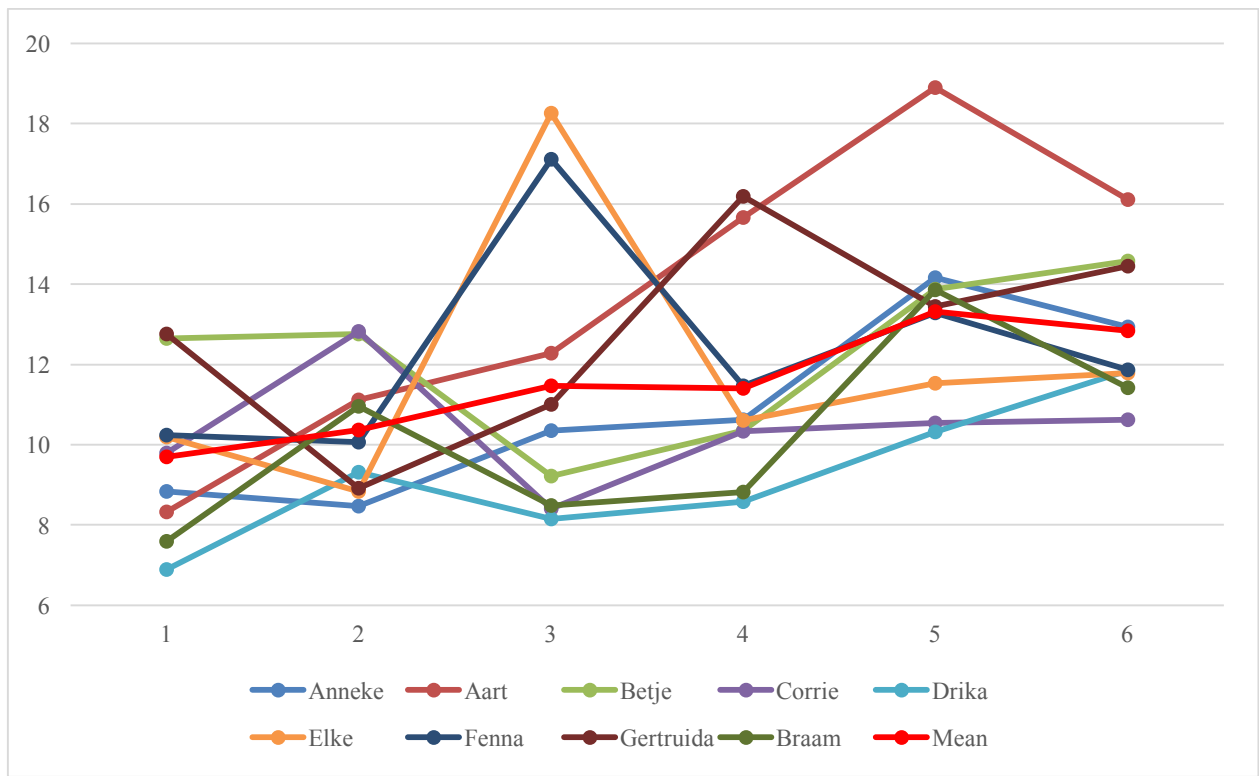


Figure 5.4 MLTU (Verspoor)

Overall, the results with regard to MLTU align with previous (mostly cross-sectional) studies (e.g., Ortega, 2003) in that MLTU increased as a function of time spent studying English (c.f., Knoch et al., 2014). The findings also support Ortega’s (2003) suggestion that ESL students may achieve larger gains in a shorter amount of time than EFL students. The participants in the Salisbury corpus, for example, on average wrote 6.031 more words per T-unit after one year of study in an ESL context. In comparison, the participants in the Verspoor corpus averaged 3.146 more words per T-unit after two years of study. In addition to context of study, the differences in gains may be due to factors such as age, hours per week studied, and motivation.

**5.2.2.2 T-units per sentence**

A positive, linear relationship between time spent studying English as a second/foreign language and mean length of T-unit was found in the Salisbury corpus ( $p = .023, \eta^2_p = .676$ ). As

students spent more time studying, they tended to include more T-units per sentence. Jalil, for example, had an average of one T-unit per sentence at the second collection point (week six). As shown in Table 5.11, which shows examples of Jalil's writing near the beginning and the end of the year, Jalil tended to use simple and complex sentences (which are comprised of a single T-unit) but avoided using compound sentences (which include at least two T-units). By collection point nine (week 43) she had increased to 1.333 T-units per sentence through the inclusion of compound/complex sentences.

*Table 5.11 Examples from the Salisbury corpus: T-units per sentence*

Collection point	Example	T-units per sentence
T2 (Week 6)	<i>Yesterday is nice day for me because The sky is raining and no sunny.</i>	1
	<i>I like the rain because I remember my country.</i>	1
T9 (Week 43)	<i>In your thinking you can not imagine how many people die per hour because of smoking and how many person die per day because they set in smoking places.</i>	2
	<i>If I can do something, the first thing I will do it is ban the smoking from all the public places and try to help the people how to quit this big problem.</i>	2

*Note.* Examples at each collection point represent contiguous sentences.

Figure 5.6 includes the average score for T-units per sentence plotted with each students' score. This trend was relatively linear for most students, though peaks and valleys did exist (see, for example the trajectories of Takako and Kamal). The exception to the general trend was again Marta, who at collection points six through eight (weeks 21-34) had her highest number of T-units per sentence (between 1.5 and 1.7), but then fell to 1.333 at the final collection point.

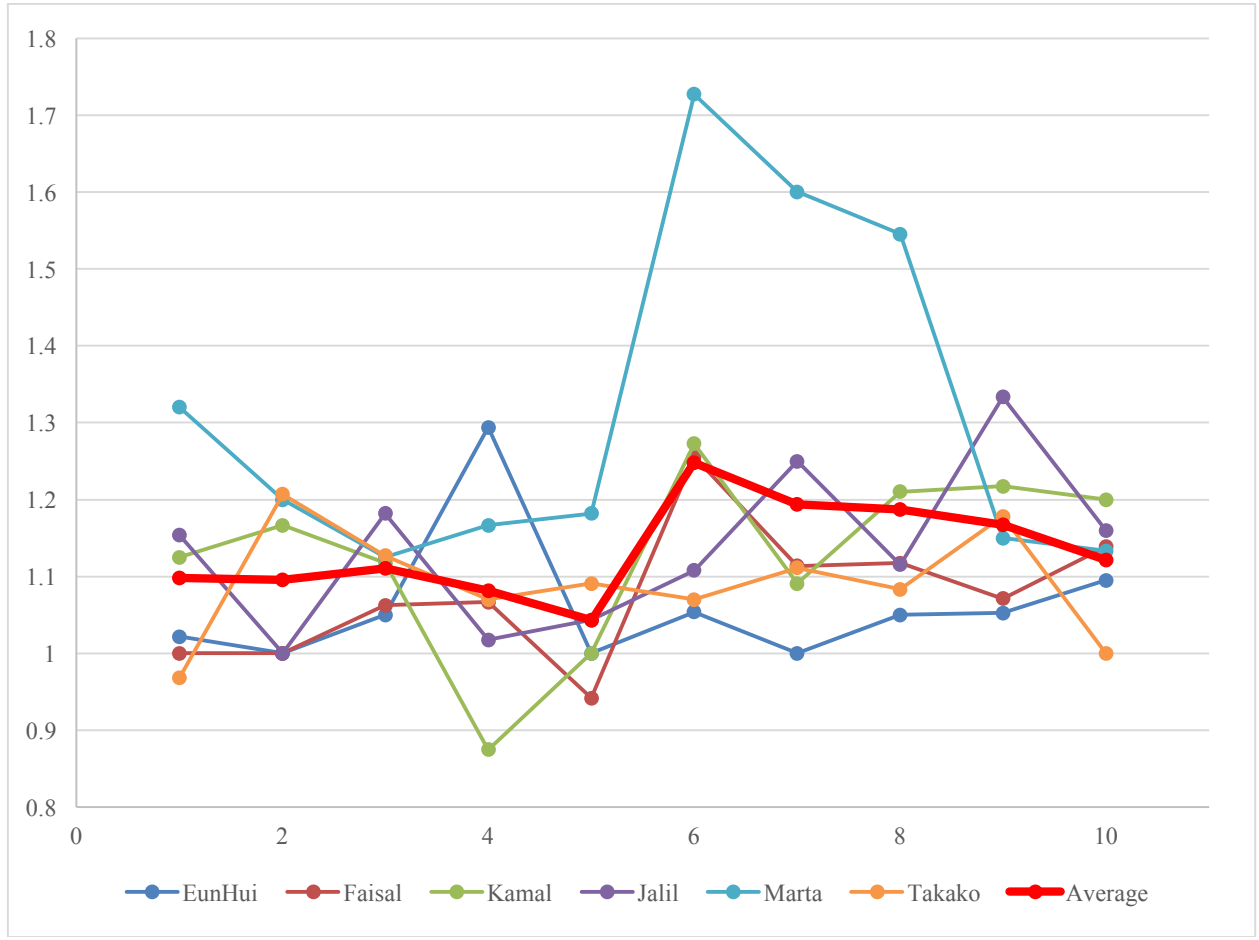


Figure 5.5 T-units per sentence (Salsbury)

The positive, significant trend for the index T-units per sentence is surprising in light of previous studies. Of the five studies reviewed that employed the index (Cooper, 1976; Homburg, 1984; Ishikawa, 1995; Lu, 2011; Monroe, 1975), only Monroe’s study of the development of second language French reported a significant relationship. Monroe found that clausal coordination decreased with proficiency, while in the Salsbury corpus clausal coordination increased with proficiency. Further research is warranted to determine the factors that contribute to this finding.



### **5.2.3 Research Questions 2b-5b results: Other TAASSC index types**

#### ***5.2.3.1 Salisbury corpus results: Other TAASSC index types***

To address research questions 3b-5b, repeated measure analysis of variance (RM ANOVA) statistics were used to determine whether a linear relationship existed between time studying English and indices of fine-grained clausal complexity, fine-grained phrasal complexity, and syntactic sophistication. TAASSC includes 353 indices related to these constructs. To meet the expectations of the statistical analyses used to examine the relationship between TAASSC indices and time (i.e., repeated measures ANOVA), the nine component scores outlined in Chapter 3 were used. All indices demonstrated a roughly normal distribution. None of the components demonstrated multicollinearity. See Table 5.12 for descriptive statistics for the selected indices.

*Table 5.12 Salsbury corpus: Mean (standard deviation) for component scores at each collection point*

Index	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Noun phrase elaboration	-0.939 (8.905)	-1.733 (4.914)	-3.061 (4.836)	0.977 (8.651)	0.012 (5.440)	-2.529 (4.679)	-1.018 (5.219)	0.178 (3.947)	4.670 (10.385)	3.442 (5.531)
Verb-VAC frequency	4.010 (4.298)	1.555 (5.004)	2.317 (3.829)	-1.001 (3.142)	0.060 (4.543)	1.830 (2.913)	-3.839 (6.852)	-1.188 (5.695)	-0.849 (8.084)	-2.895 (1.650)
Nouns as modifiers and modifier variation	0.659 (5.207)	-1.984 (1.189)	-0.664 (2.338)	1.848 (4.139)	-0.291 (2.527)	0.557 (1.927)	-0.229 (3.164)	0.727 (1.093)	-0.707 (2.965)	0.083 (2.375)
Determiners	-2.370 (3.304)	0.842 (3.606)	0.003 (3.260)	0.074 (3.756)	1.248 (2.289)	0.487 (3.517)	0.097 (2.706)	-0.774 (3.917)	-1.395 (4.171)	1.788 (2.792)
VAC frequency and direct objects	-0.785 (1.939)	0.686 (2.879)	-0.043 (2.622)	1.025 (3.236)	1.072 (1.732)	0.824 (3.258)	0.165 (1.729)	-2.608 (4.610)	-0.679 (2.404)	0.342 (1.095)
Association Strength	0.654 (5.187)	-1.947 (1.851)	-1.412 (1.598)	1.114 (2.733)	-0.294 (1.613)	0.354 (2.010)	0.035 (1.871)	1.369 (2.138)	0.961 (2.062)	-0.834 (1.426)
Diversity and Frequency	-0.928 (4.840)	1.405 (2.711)	-0.436 (1.640)	0.405 (3.633)	-0.058 (2.998)	-1.526 (2.044)	-0.070 (0.619)	0.319 (1.569)	-0.008 (2.555)	0.897 (2.202)
Possessives	0.101 (3.564)	0.524 (2.880)	1.770 (4.051)	-0.210 (1.134)	0.940 (1.389)	-0.168 (1.105)	0.250 (1.429)	0.281 (1.093)	-1.141 (1.303)	-2.345 (1.338)
Frequency	0.689 (1.808)	0.949 (2.259)	0.233 (2.792)	-0.574 (2.690)	0.894 (1.309)	0.877 (2.313)	0.676 (2.086)	-1.115 (1.829)	-0.607 (2.980)	-2.022 (2.164)

RM ANOVA statistics were conducted using the nine TAASSC component indices. The results indicated that significant negative linear trends with large effects existed between time and verb-VAC frequency ( $p = .010$ ,  $\eta^2_p = .768$ ), and possessives ( $p = .035$ ,  $\eta^2_p = .624$ ). See Table 5.13 for a summary of the results.

*Table 5.13 Repeated measure analysis of variance results for TAASSC component indices*

Index	F	p	$\eta^2_p$
Noun phrase elaboration	3.011	.143	.376
Verb-VAC frequency	16.595	.010*	.768
Nouns as modifiers and modifier variation	.065	.810	.013
Determiners	1.107	.341	.181
VAC frequency and direct objects	1.925	.224	.278
Association Strength	.437	.538	.080
Diversity and Frequency	.166	.701	.032
Possessives	8.282	.035*	.624
Frequency	3.246	.131	.394

*Note.* \* indicates  $p < .05$

### **5.2.3.2 Verspoor corpus results: Other TAASSC index types**

To address research questions 2b-5b, repeated measure analysis of variance (RM ANOVA) statistics were used to determine whether a linear relationship existed between time studying English and indices of fine-grained clausal complexity, fine-grained phrasal complexity, and syntactic sophistication. TAASSC includes 353 indices related to these constructs. To meet the expectations of the statistical analyses used to examine the relationship between TAASSC indices and time, the nine component scores, which are described in Chapter 3, were used. All indices demonstrated a roughly normal distribution. None of the components demonstrated multicollinearity. See Table 5.14 for descriptive statistics for the selected indices.

*Table 5.14 Verspoor corpus: Mean (standard deviation) for component scores at each collection point*

Index	T1	T2	T3	T4	T5	T6
Noun phrase elaboration	-1.306 (3.132)	2.075 (4.828)	0.948 (4.201)	1.425 (5.606)	-2.110 (4.132)	-1.033 (6.186)
Verb-VAC frequency	5.344 (4.771)	4.177 (3.771)	-0.003 (4.656)	-1.704 (1.683)	-4.557 (3.456)	-3.258 (3.158)
Nouns as modifiers and modifier variation	-0.410 (2.857)	0.144 (2.550)	0.131 (2.248)	-0.463 (2.805)	-0.204 (2.692)	0.801 (2.946)
Determiners	-0.841 (1.964)	1.596 (3.760)	0.648 (3.157)	1.271 (3.528)	-1.753 (2.156)	-0.921 (2.671)
VAC frequency and direct objects	2.698 (3.032)	-1.210 (1.902)	0.126 (2.185)	-2.090 (1.709)	-0.444 (3.301)	0.919 (2.178)
Association Strength	-1.737 (3.401)	-0.556 (2.514)	1.727 (1.989)	0.816 (2.630)	-0.133 (1.513)	-0.118 (2.056)
Diversity and Frequency	-1.494 (2.080)	-0.689 (2.252)	-0.345 (2.464)	1.491 (1.459)	0.968 (0.963)	0.070 (1.415)
Possessives	0.207 (2.781)	0.293 (2.851)	-0.713 (1.370)	1.667 (2.589)	-0.658 (1.439)	-0.797 (1.850)
Frequency	1.538 (1.858)	0.408 (2.743)	0.226 (1.075)	-1.571 (2.624)	-0.837 (1.419)	0.236 (1.486)

Repeated measures analysis of variance (RM ANOVA) statistics were then conducted using the nine TAASSC component indices. The results indicated that significant negative linear trends with large effects existed between time and verb-VAC frequency ( $p < .001$ ,  $\eta^2_p = .855$ ), diversity and frequency ( $p = .014$ ,  $\eta^2_p = .551$ ) and frequency ( $p = .019$ ,  $\eta^2_p = .518$ ). See Table 5.15 for a summary of the results.

*Table 5.15 Repeated measure analysis of variance results for TAASSC component indices*

Index	F	p	$\eta^2_p$
Noun phrase elaboration	.521	.491	.061
Verb-VAC frequency	47.295	.000**	.855
Nouns as modifiers and modifier variation	.260	.624	.031
Determiners	1.349	.279	.144
VAC frequency and direct objects	1.803	.216	.184
Association Strength	.974	.353	.109
Diversity and Frequency	9.798	.014*	.551
Possessives	.839	.386	.095
Frequency	8.608	.019*	.518

*Note.* \* indicates  $p < .05$ ; \*\* indicates  $p < .001$

#### 5.2.4 Research Questions 2b-5b discussion: Other TAASSC index types

In order to address Research Questions 3b-6b, RM ANOVA statistics were conducted to determine if a linear relationship existed between any of the TAASSC component scores and time spent studying English. Significant linear results were observed for three components, including the possessives component, the diversity and frequency component, and the frequency component. The results varied according to learner corpus, and are discussed in detail below.

##### 5.2.4.1 Discussion: Verb-VAC frequency

A significant negative linear trend was observed between time spent studying English and the verb-VAC frequency component in both the Salisbury corpus ( $p = .010$ ,  $\eta^2_p = .768$ ) and the Verspoor corpus ( $p < .001$ ,  $\eta^2_p = .855$ ). Figure 5.6 and Figure 5.7 show the trends for each index included in the component in the Salisbury and Verspoor data, respectively. In both datasets, all indices follow a similar trend over time, suggesting component convergence.

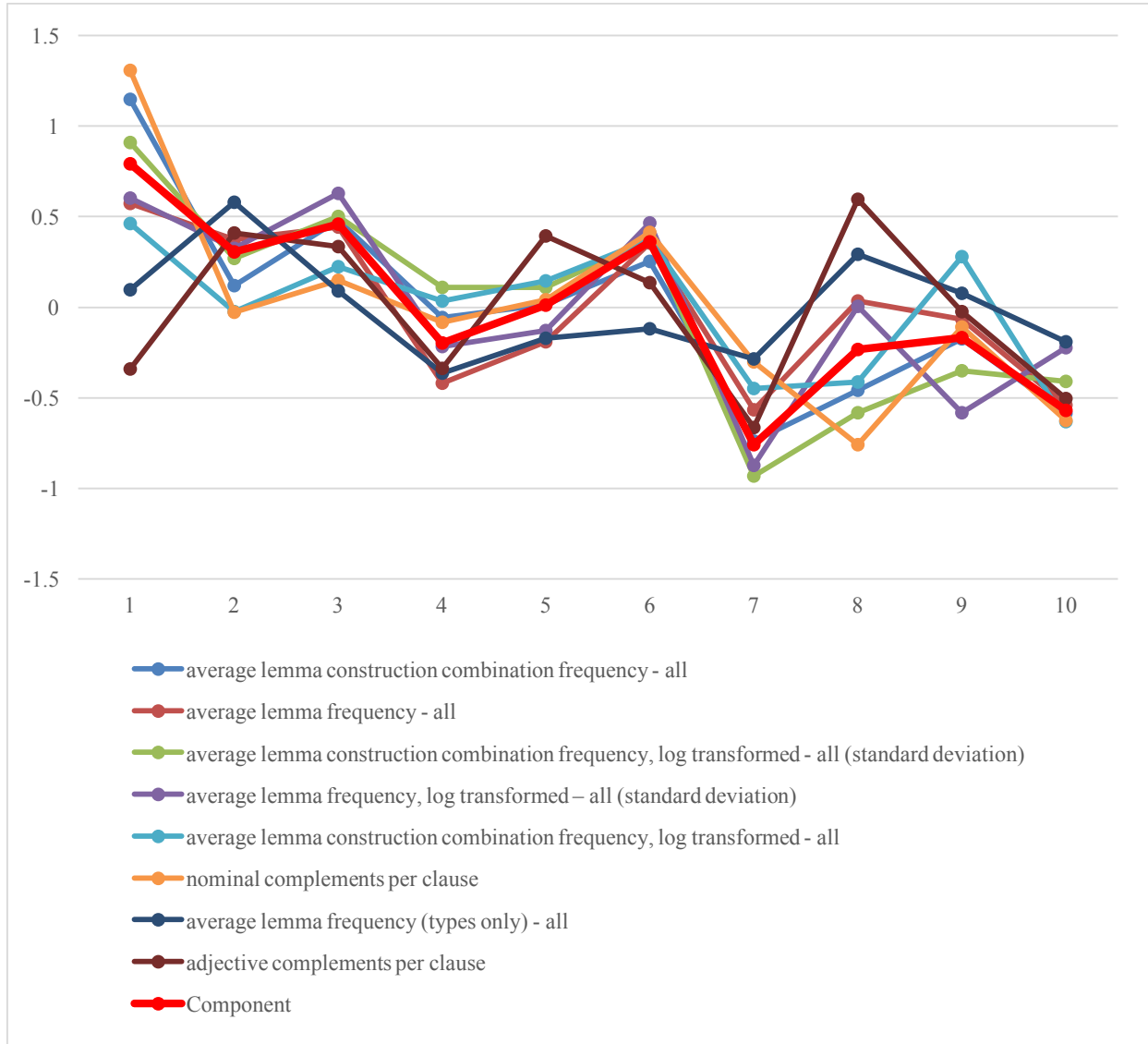


Figure 5.6 Trends for indices included in the Verb-VAC frequency component (Salsbury)

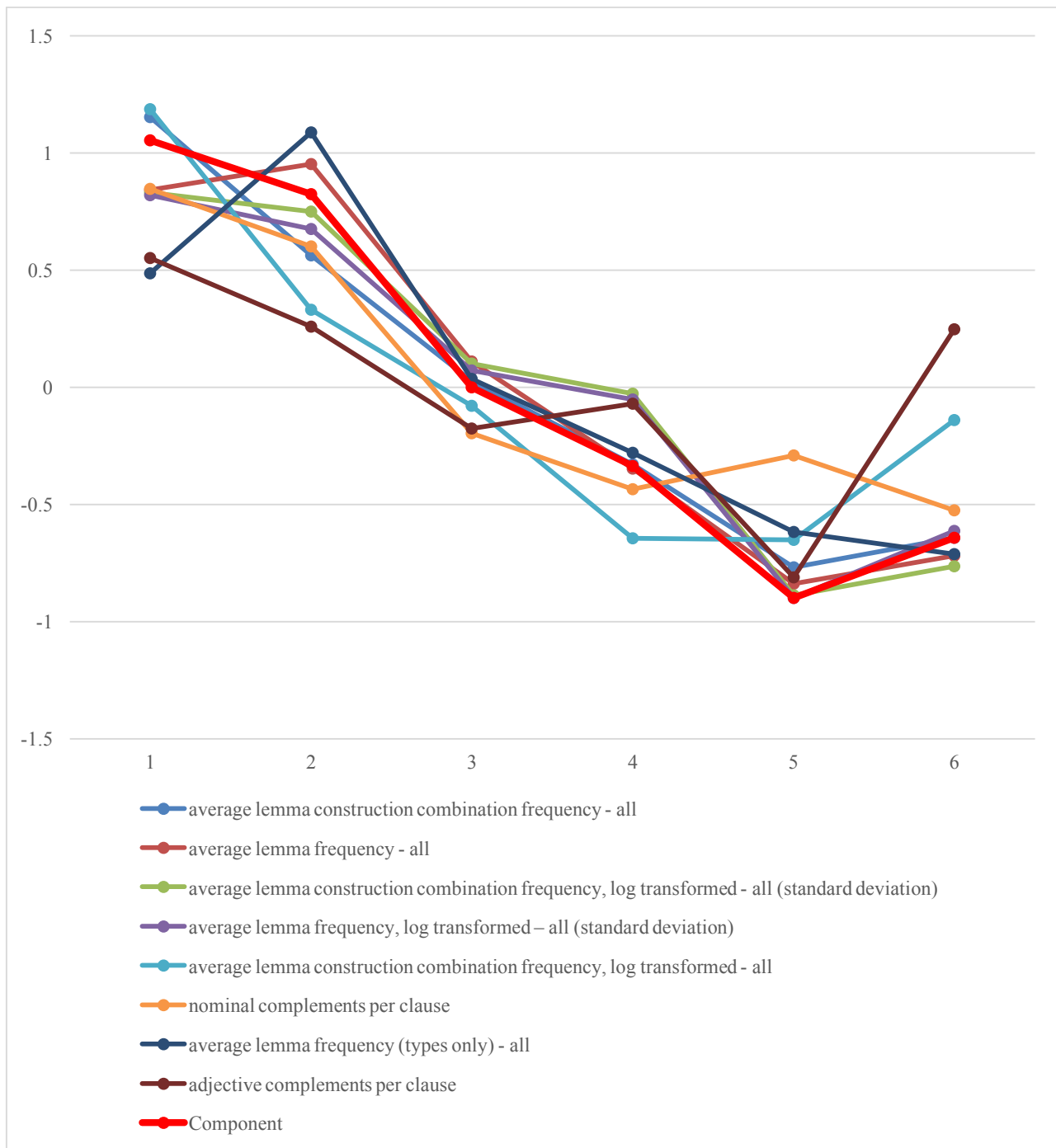


Figure 5.7 Trends for indices included in the Verb-VAC frequency component (Verspoor)

The results suggest that as individuals spend time studying English, they tend to use less frequent verb-VAC combinations. In the Salisbury corpus, Marta's free writes from the first collection point (week 3) have an average verb-VAC combination frequency score of

315,730.121, which is near the mean. Table 5.16 includes example sentences from Marta, and Table 5.17 includes frequency information for each VAC in the examples. Early in the study, Marta uses some relatively low-frequency verb-VAC combinations (see examples 1a, 2a, and 3). However, she also uses a large percentage of high-frequency verb-VAC combinations (see example 1b). By the final collection point, however, Marta's writing is characterized by lower frequency verb-VAC combinations. She still uses high frequency verb-VAC combinations as in example 4, but verb-VAC combinations such as those in example 5 are much more common.

Table 5.16 Examples from Marta, T1 (week 3) and T10 (week 50)

T1	Ex. 1	
(week 3)	(2 VACs)	<p>PRP (I) nsubj VBP (think) ccomp NN (cook) nsubj VBZ (is) acomp JJ (difficult) punct (.)</p>
	Ex. 2	
	(2 VACs)	<p>PRP (I) nsubj VBP (think) PRP (me) nsubj VB (put) acomp JJ (fat) punct (.)</p>
	Ex. 3	
	(1 VAC)	<p>IN (In) NNP (South American) nn NNP (we) prep_in PRP (we) nsubj VBP (eat) dobj RB (much) punct (.)</p>
T10	Ex. 4	
(week 50)	(1 VAC)	<p>DT (some) det NNS (people) nsubj VBP (are) RB (very) advmod JJ (allergic) prep_at IN (at) NN (smoke) prep_of IN (of) DT (the) det NN (cigarette)</p>
	Ex. 5	
	(2 VACs)	<p>PRP (I) nsubj VBP (think) PRP (I) nsubj VBP (have) RB (very) advmod JJ (good) amod NNS (reasons) WDT (that) rcmmod MD (can) nsubj aux VB (convince) dobj NN (smoking) nn NNS (people)</p>



*Table 5.17 Examples from the Salisbury corpus: Verb-VAC combination frequency*

Collection point	Example	Verb	VAC	Frequency
T1 (week 3)	Ex. 1a	think	nsubj-v-ccomp	80,783
	Ex. 1b	be	nsubj-v-acomp	1,328,596
	Ex. 2a	think	nsubj-v-ccomp	80,783
	Ex. 2b	put	nsubj-v-acomp	10
	Ex. 3	eat	prep_in-nsubj-v-dobj	43
T10 (week 50)	Ex. 4	be	nsubj-v-acomp	1,328,596
	Ex. 5a	have	nsubj-v-dobj	212,970
	Ex. 5b	convince	nsubj-v-dobj	321

These results provide support for usage-based theories of language development (Behrens, 2009; Ellis, 2002a; Tomasello, 2003). Usage-based theories suggest that frequency is the driving force in language learning: More frequently occurring items in the input will be learned earlier/more easily than less frequent items. This seems to be evidenced in the results across writing types (free writes vs. essays), instructional settings (ESL vs. EFL), and ages (middle-school students vs. adults). Learners tend to use more frequent verb-VAC combinations, which are hypothesized to be easier to learn, near the beginning of each study, but after exposure to English tend to use less frequent verb-VAC combinations, which are hypothesized to be more likely to be learned at later stages of development. Previous studies (Ellis & Ferreira-Junior, 2009b; Lieven et al., 1997) have demonstrated this phenomenon in oral modes, with regard to a small set of VACs, and with a small amount of input recorded. This study has indicated that usage-based theories of language acquisition are evident in written modes, and across a comprehensive set of VACs. This study has also suggested that reference corpus frequencies are workable proxies for language learner input (see also Römer et al., 2015, 2014). A strong

relationship between COCA frequencies and language development was found, suggesting (from a usage-based perspective) that the frequency profiles of VACs experienced by the participants in each study is comparable to those in COCA.

Although a significant negative linear trend was observed between time spent studying English and the verb-VAC frequency component, individual results varied somewhat for individuals in each dataset. Figure 5.8 and Figure 5.9 include individual component scores plotted with the mean component score at each time point for the Salsbury and Verspoor corpora respectively. This data suggests that although participants generally use less frequent verb-VAC combinations, the pattern is not strictly linear, which may be explained by theories related to Complex Systems (Larsen-Freeman & Cameron, 2008; Larsen-Freeman, 1997). In the Salsbury corpus, for example (see Figure 5.8), pronounced peaks and valleys can be seen in the values for each participant. In particular, at collection point one (week 3), Faisal's scores for the verb-VAC frequency component generally follow a negative trend until collection point seven (week 26). Between collection points seven and nine, however, his scores rise sharply, followed by a decline for collection point ten. Similar (but less pronounced) trends can be found in the Verspoor corpus. The component scores for some participants, such as Bram and Drika follow a consistent negative trend, but others have scores that are much more erratic. Eike, for example, begins the study with component scores near the mean. At the second collection point she reaches a high point, followed by her lowest overall component score at collection point 3, after which she maintains relatively stable scores.

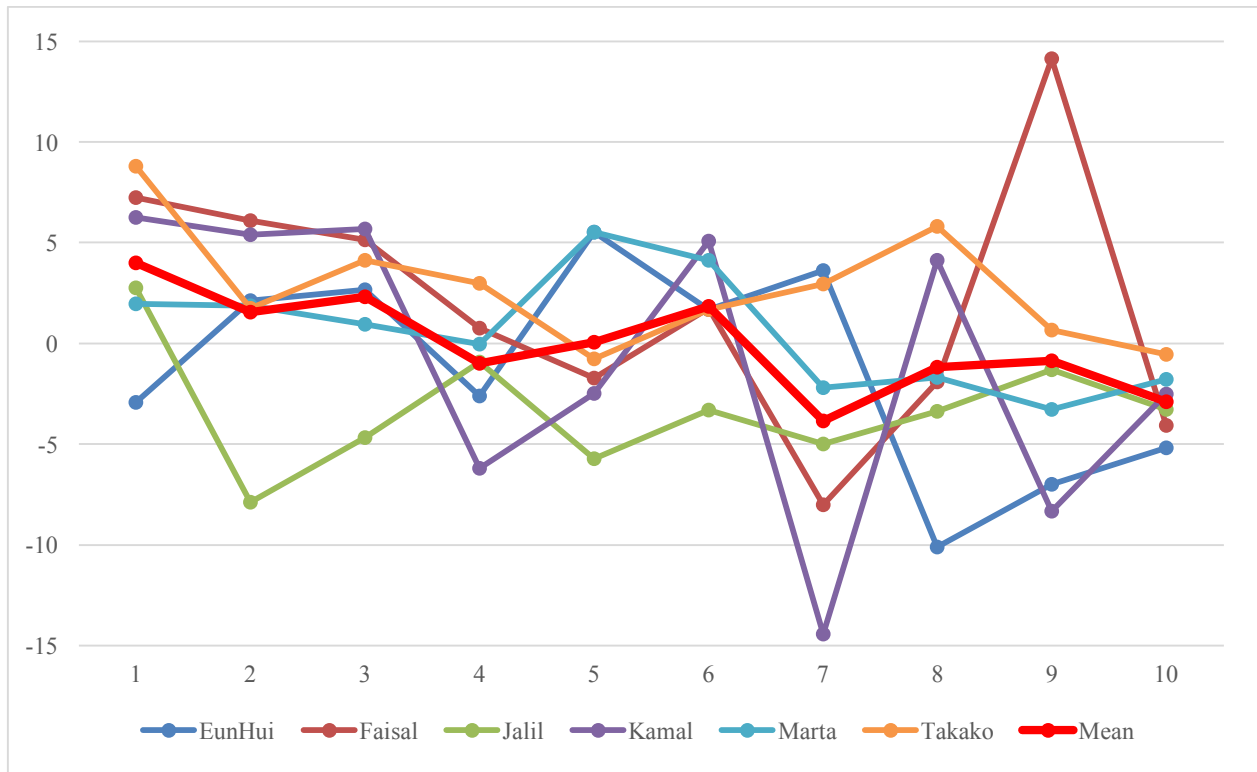


Figure 5.8 Verb-VAC frequency component results (Salsbury)

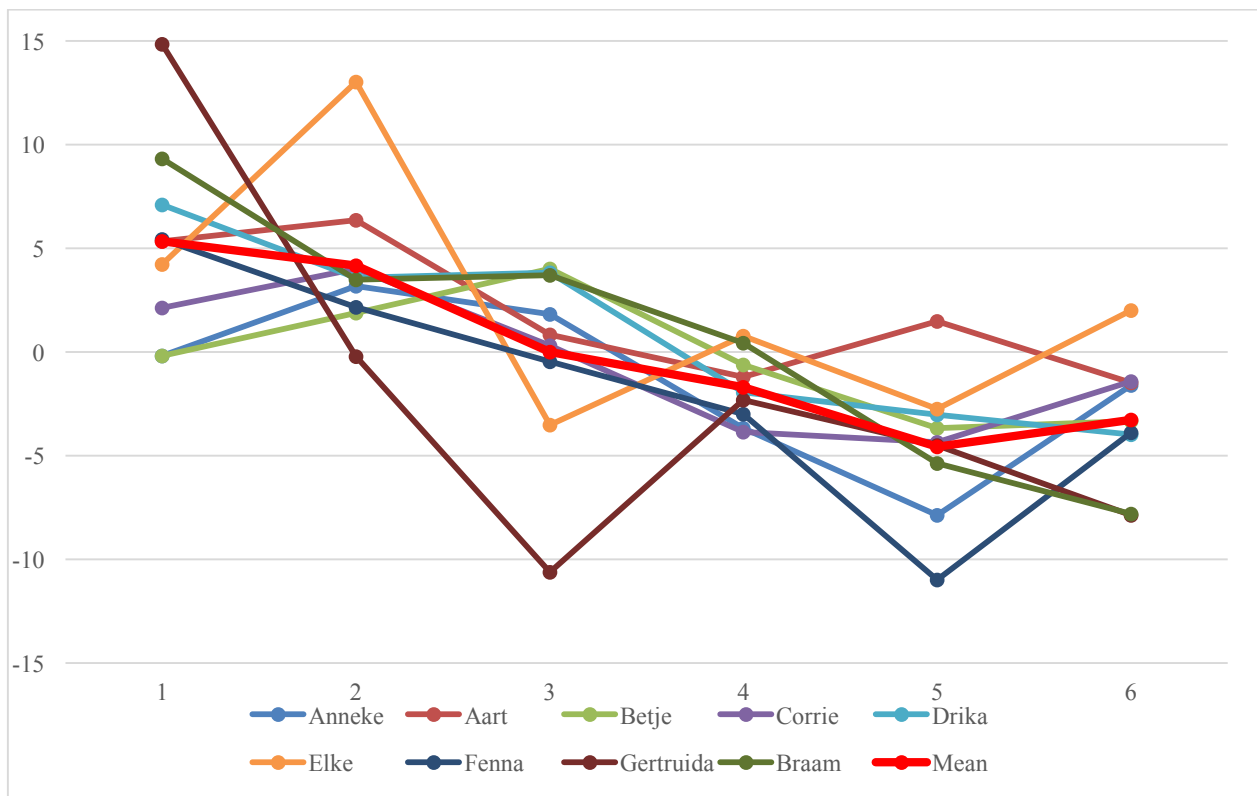


Figure 5.9 Verb-VAC frequency component results (Verspoor)

#### 5.2.4.2 *Discussion: Diversity and frequency*

In the Verspoor corpus (but not in the Salsbury corpus), a significant positive linear trend was observed for the diversity and frequency component ( $p = .014$ ,  $\eta^2_p = .551$ ). Figure 5.10 shows the trends for each index included in the component. The three TTR indices in the component, follow similar positive trends. The index average lemma construction frequency (types only), however, followed a negative trend, demonstrating non-convergence in the component. Further discussion of this component will focus on the three TTR indices that are representative of the component scores.

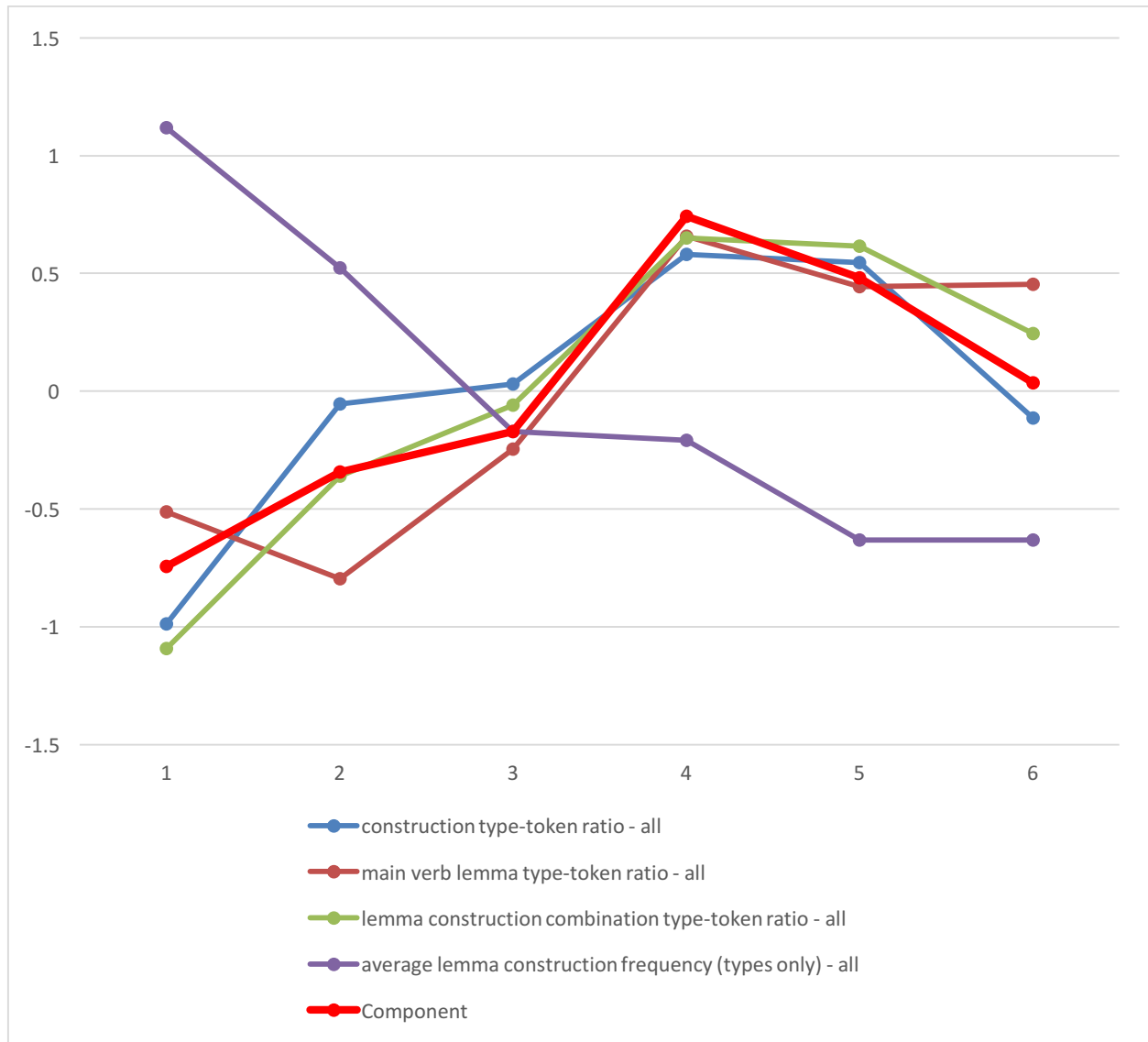


Figure 5.10 Indices included in the diversity and frequency component (Verspoor)

The results suggest that as individuals spend time studying English, they tend to produce more diverse VACs, main-verb lemmas, and verb-VAC combinations. At the first collection point, participants averaged a VAC TTR of .707, indicating that approximately 30% of VAC instances are repeated. Of the 203 VAC instances written by the Dutch students at the first collection point, 34.5% of the tokens are *nsubj-v-acomp* (13.3%), *nsubj-v-ncomp* (10.8%), or *nsubj-v-dobj* (10.3%), while 42.4% comprise VAC tokens that only occur once. By collection

point four participants averaged a VAC TTR of .891, indicating that only approximately 11% of VAC instances are repeated. Of the 238 VAC tokens written by Dutch students at collection point 4, only 14.3% of the tokens are *nsubj-v-acomp* (6.3%), *nsubj-v-ncomp* (2.9%), or *nsubj-v-dobj* (5.0%), while 61.3% comprise VAC tokens that only occur once. By the final collection point, the average drops to .818, indicating that approximately 18% of VAC instances are repeated. Overall, this suggests that as individuals spend time studying English, they tend to rely less on “teddy bear” (Ellis & O’Donnell, 2014) VACs such as copular constructions (i.e., *nsubj-v-acomp* and *nsubj-v-ncomp*) and monotransitives (e.g., *nsubj-v-dobj*) to express their ideas, and use a wider variety of VACs. However, this trend was not observed in both corpora, suggesting that this finding may be context specific. Future research in this area is warranted.

Although a significant positive linear trend was observed between time spent studying English and the diversity and frequency component, individual results varied somewhat for individuals in each dataset. Figure 5.11 includes individual component scores plotted with the mean component score at each time point. Some students (e.g., Aart and Braam), follow relatively linear positive trends. Others, such as Betje and Gertruida, however, clearly do not.

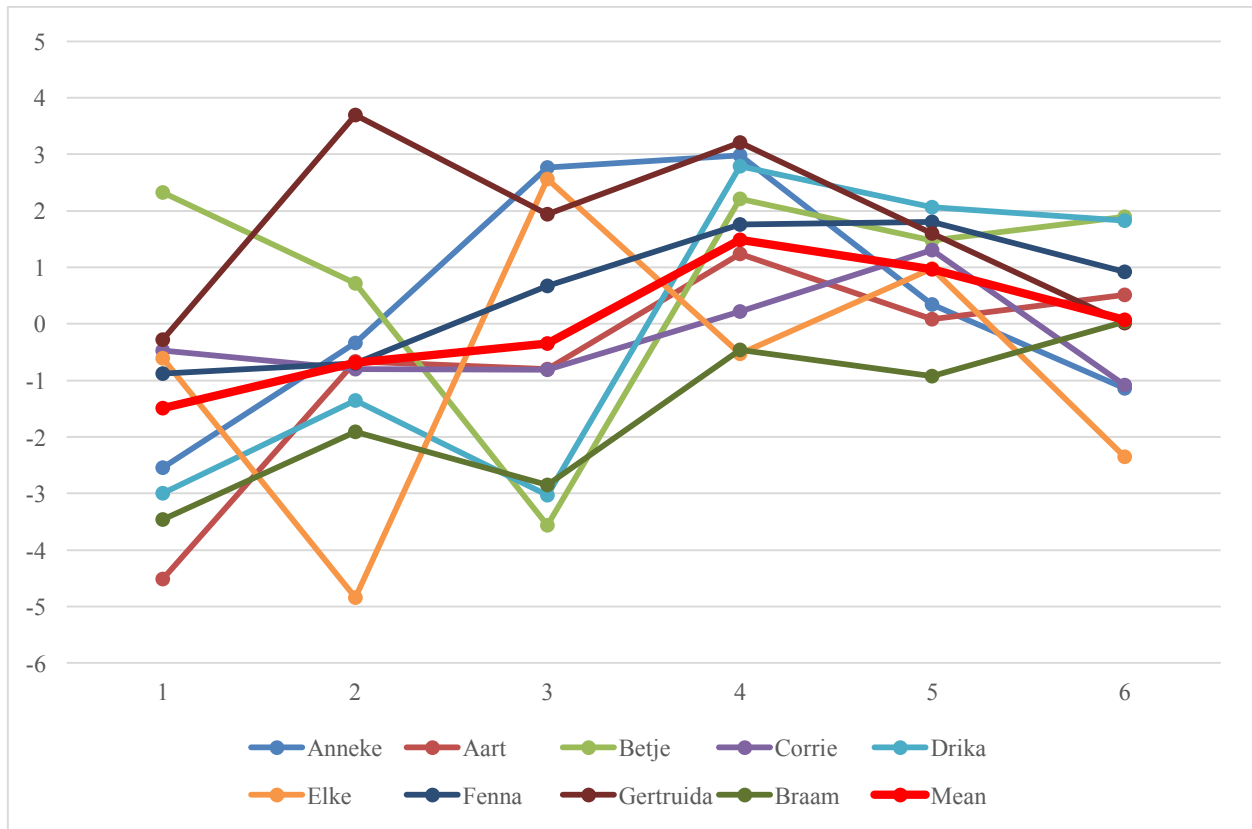


Figure 5.11 Diversity and frequency component results (Verspoor)

#### 5.2.4.3 Discussion: Possessives

In the Salisbury corpus (but not the Verspoor corpus), a significant negative linear trend was observed between time spent studying English and the use of possessive noun modifiers ( $p = .035$ ,  $\eta^2_p = .624$ ). Figure 5.12 shows the trends for each index included in the component. All component indices follow a similar trend over time, suggesting component convergence.

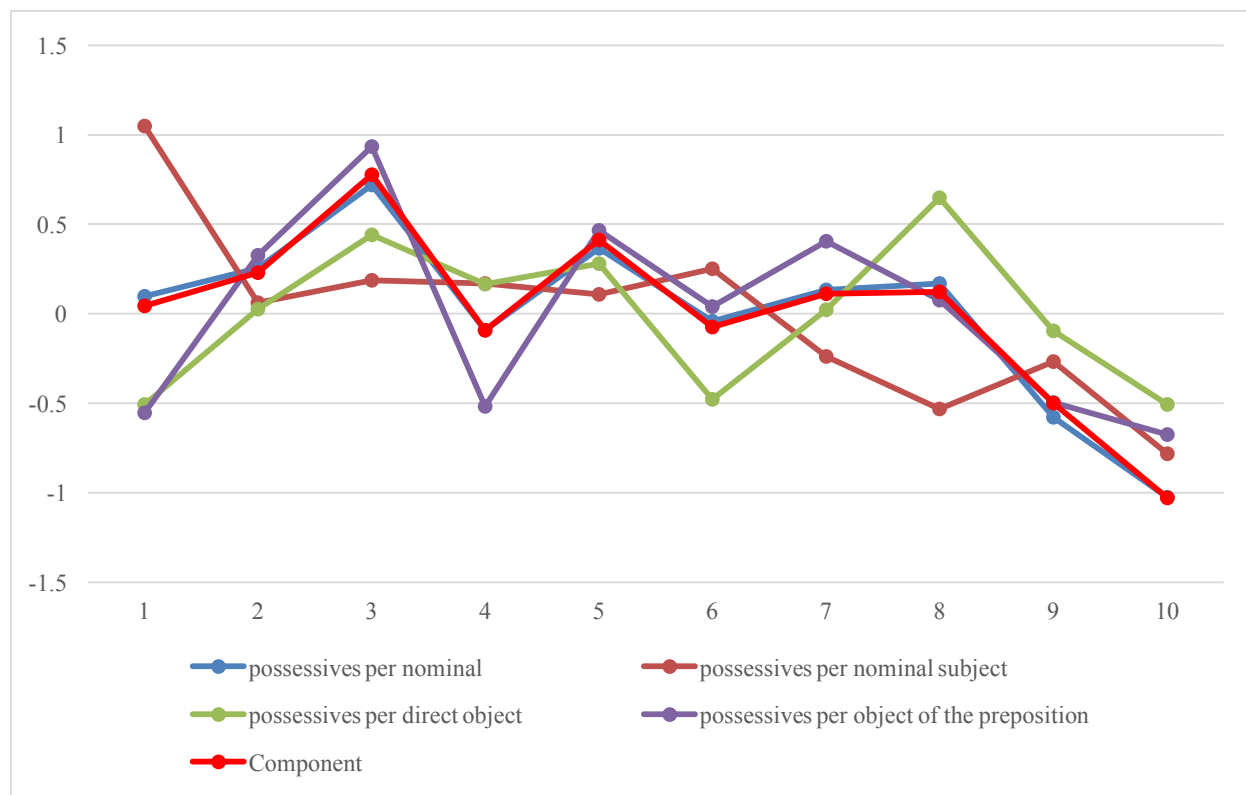


Figure 5.12 Trends for indices included in the possessives component (Salsbury)

The results suggest that near the beginning of the year studying English, the students used more possessives, and as the year progressed they used fewer. EunHui, for example, used possessives (e.g., *my country's* peoples, *their* family) relatively frequently during the first collection period (Week 3), and uses very few at collection points nine and ten (weeks 43 and 50) near the end of the year. See Table 5.18 for examples of the types of nominal phrases written by EunHui at the beginning and end of the year. To some degree, the results align with Biber et al.'s (2011) proposed complexity developmental stages. Biber et al. suggest that one characteristic of intermediate level writing (i.e., stage 3 of 5) is possessive nouns as premodifiers, which are a feature of fiction writing. Within this framework, it could be hypothesized that individuals in the Salsbury corpus began at an intermediate level of proficiency and moved toward more academic and higher proficiency writing. A potentially complementary explanation



for the change in use of possessives is the different registers/genres used in EunHui's writing. During week 3, she discusses her thoughts and feelings regarding daily life as she adjusts to living in a new country. During weeks 43 and 50, however, she addresses argumentative topics, which she addresses in a less personal manner. What is not clear, however, is whether her shift from writing that is more characteristic of fiction to more academic topics is due to an increase in proficiency or an unrelated shift in genre. At some points in the study, for example, it is apparent that some participants used their free writes as a site for practicing essays that were assigned by a teacher. Furthermore, this trend was not observed in the Verspoor corpus, suggesting that this finding may be context specific. Future research is warranted in this area.

*Table 5.18 Examples from the Salisbury corpus: Possessives component*

Collection point	Example
T1 (Week 3)	<i>Life style is different to <b>my</b> country.</i>  <i><b>My</b> country's peoples work until on Saturday in the noon so they go to the rest place <b>their</b> family together.</i>
T9 (Week 43)	<i>In Korea, the educational system has to change from remembering studying to finding basic principle system. [no possessives]</i> <i>When the system is changed, a lot of students can have interesting in their studying and study much more with <b>their</b> joyful mind.</i>
T10 (Week 50)	<i>You can often experience that people smoke in permitted public places. [no possessives]</i> <i>What do you feel after watching it? [no possessives]</i> <i>I always felt the smell caused <b>my</b> bad feeling.</i>

*Note.* Examples at each collection point represent contiguous sentences written by EunHui.

Although a significant linear trend was observed with regard to the use of pronouns, individual results varied. Figure 5.13 comprises the average possessive component scores for each collection point plotted with the individual scores. Some students, such as EunHui followed a general negative trend in possessive use (though peaks and valley are observed). Others,

however, varied widely. During the first collection period (week three), Faisal used no possessives, but by the third collection period he (along with Takako) reached his high point in possessive use.

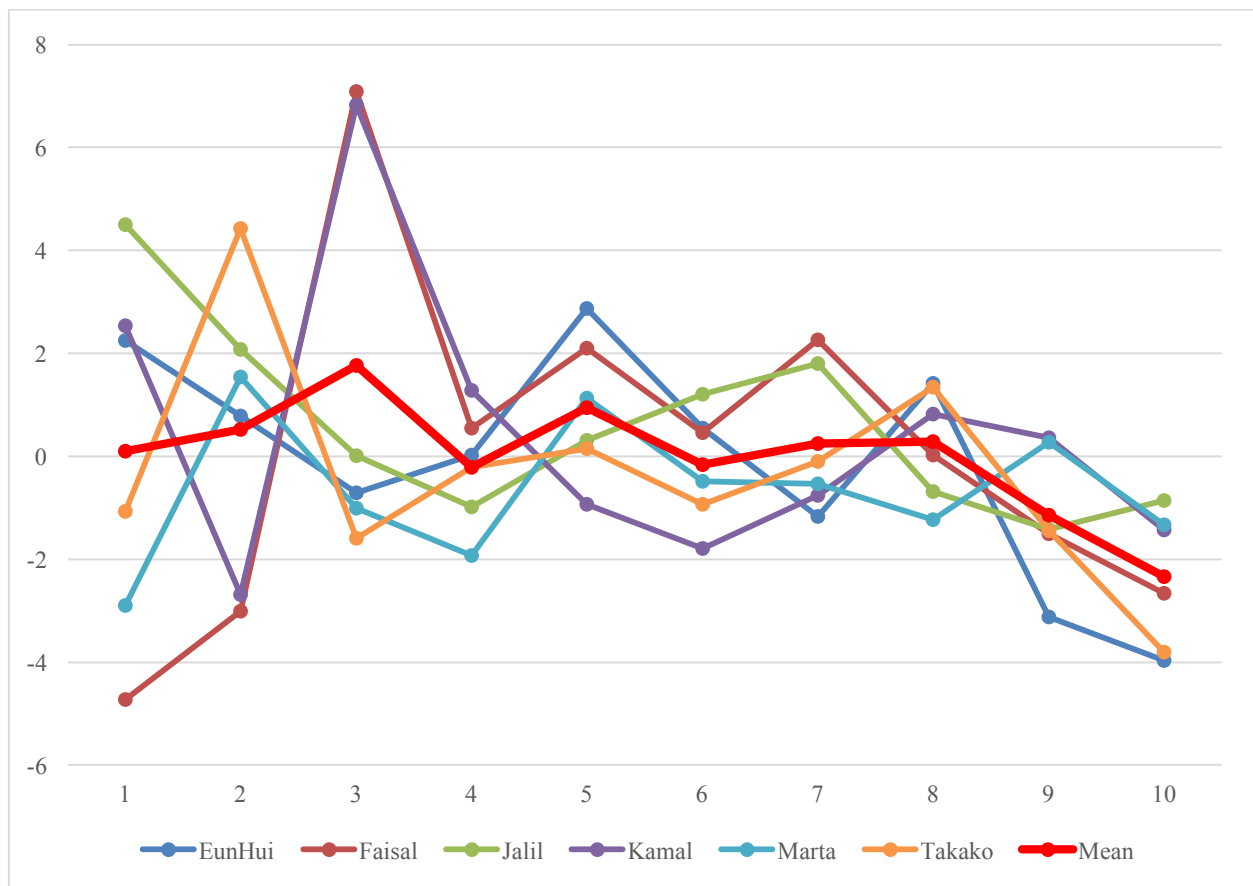


Figure 5.13 Possessives component results (Salsbury)

#### 5.2.4.4 Discussion: Frequency

In the Verspoor corpus (but not in the Salsbury corpus), significant negative linear trends were observed for the frequency component ( $p = .019$ ,  $\eta^2_p = .518$ ). Figure 5.14 shows the trends for each index included in the component. All component indices follow a relatively similar trend over time, suggesting component convergence.

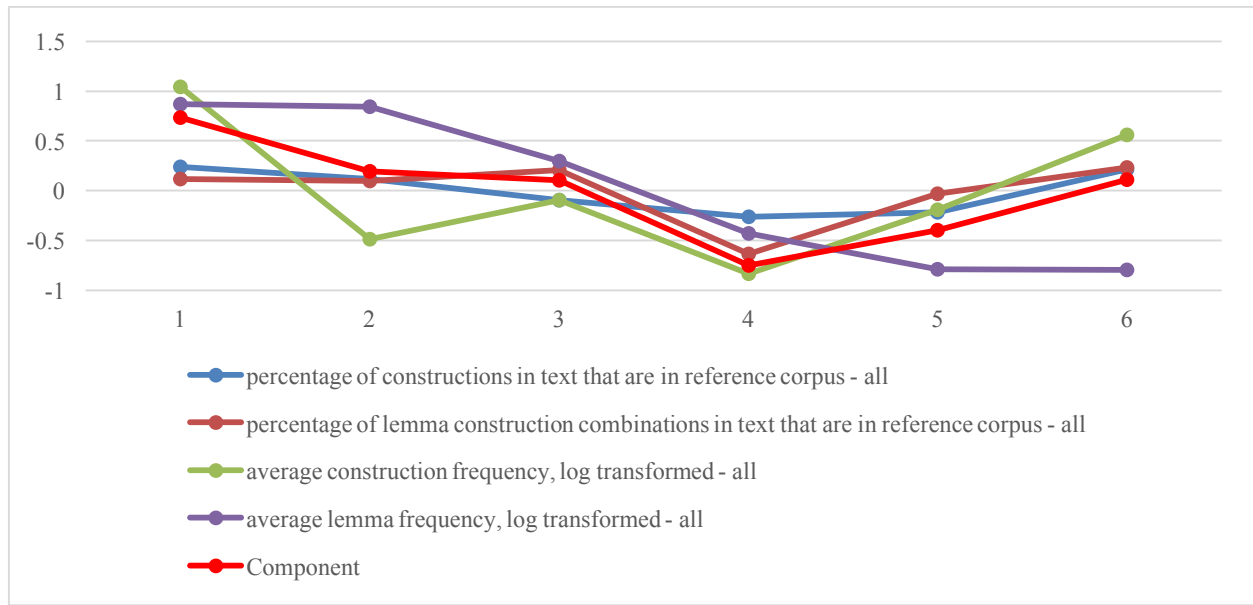


Figure 5.14 Trends for indices included in the frequency component (Verspoor)

The results suggest that as students spend more time studying English they tend to use fewer constructions and verb-VAC combinations that are attested in COCA, and tend to use lower frequency VACs and main verb lemmas. Fenna, for example, tended to use more frequent main verb lemmas near the beginning of the study, but near the end was on average using less frequent main verb lemmas. See Table 5.19 for examples of frequent and infrequent main verb lemmas used by the students in the Verspoor corpus during the first two and last two essays. This generally supports usage-based theories of language learning, which posit that frequent items in the input will be learned earlier/more easily than items that are less frequent in the input (Behrens, 2009; Ellis, 2002a; Tomasello, 2003).

*Table 5.19 Examples of main verb use by Fenna in first and last essay*

Essay	VAC	Main Verb Lemma	Frequency (logarithm transformed)
1	<i>When I <b>am</b> at school</i>	be	6.808
	<i>I <b>see</b> my friends</i>	see	5.677
	<i>and then I <b>have</b> a conversation with them</i>	have	6.081
			<b>Mean = 6.189</b>
6	<i>I <b>know</b></i>	know	5.666
	<i>it <b>makes</b> everyone equal</i>	make	5.788
	<i>and <b>looks</b> really nice</i>	look	5.541
	<i>but I still don't <b>agree</b></i>	agree	4.668
			<b>Mean = 5.416</b>

Although a significant linear trend was observed for the frequency component in the Verspoor corpus, individual results varied. Figure 5.15 comprises the longitudinal results for the frequency component with regard to the Verspoor data. Some participants, such as Anneke and Fenna, tended to follow a linear negative trend, while considerable peaks and valleys were observed for other participants. The lowest frequency component value for Corrie, for example, was observed for the second essay, and the lowest frequency component value for Aart was observed for the fourth essay.

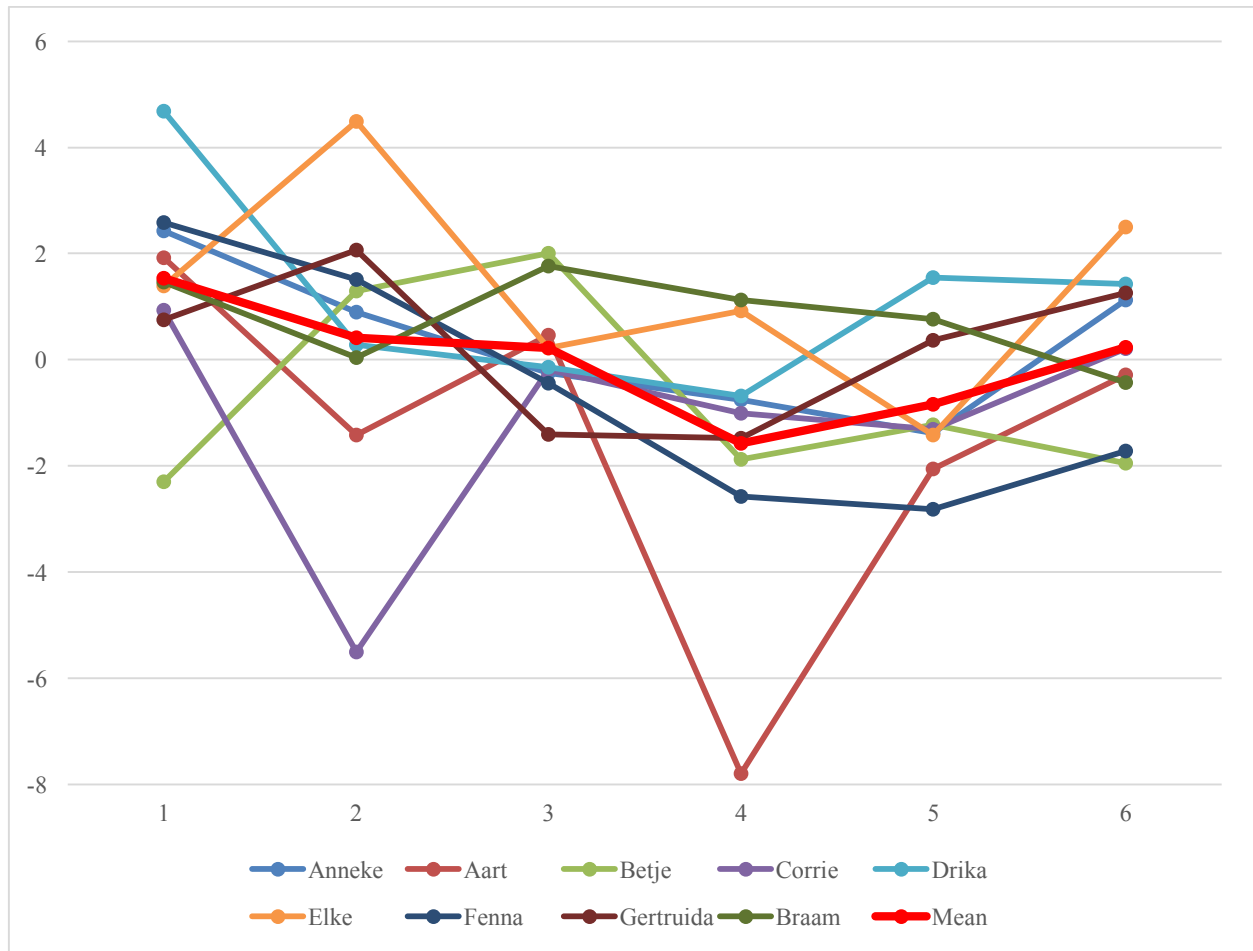


Figure 5.15 Frequency component results (*Verspoor*)

### 5.3 Summary of findings

This chapter investigated longitudinal syntactic development in language learners in two distinct contexts. Below, the findings related to each research question are summarized, followed by overall implications, limitations, and future directions.

#### 5.3.1 Research Question 1b: Syntactic Complexity Analyzer indices

A significant linear trend with a large effect was observed for the index mean length of T-unit in both longitudinal learner corpora. These results, along with a number of previous studies (Lu, 2011; Ortega, 2003; Wolfe-Quintero et al., 1998) provide strong evidence that as language learners become more proficient, they tend to write longer T-units. Another traditional index, T-

units per sentence demonstrated a significant linear trend with large effects in the Salsbury longitudinal corpus, but not in the Verspoor corpus. Writers included more clausal coordination in their sentences as they became more proficient in English. These results were somewhat surprising in light of previous research that has either found no connection or a negative relationship between T-units per sentence and proficiency (Wolfe-Quintero et al., 1998). This suggests that this finding for the Salsbury corpus may be due to construct irrelevant factors such as writing topic (and bears further investigation).

### **5.3.2 Research Question 2b: Fine-grained clausal complexity**

None of the TAASSC component indices feature fine-grained indices of clausal complexity prominently, making conclusions regarding the relationship between fine-grained clausal complexity and longitudinal growth somewhat difficult. Two indices of clausal complexity (nominal complements per clause and adjective complements per clause) were included in the verb-VAC component, both of which demonstrated a significant linear trend with large effects in both the Salsbury and the Verspoor data. The results suggest that as individuals become more proficient users of English, they tend to use fewer copular constructions. This can be explained in relation to usage-based theories of language learning (Behrens, 2009; Ellis, 2002a; Tomasello, 2003), which suggests that frequent constructions will be learned earlier than less frequent constructions. Both copular constructions with nominal complements and adjective complements are highly frequent in COCA, suggesting that they are frequent in learner input and therefore are learned early. Following this supposition, as learners have more exposure to linguistic input, they may learn to use less frequent constructions, which may lead to less reliance on copular constructions.

### **5.3.3 Research Question 3b: Fine-grained phrasal complexity**

Four of the nine TAASSC indices feature indices of fine-grained phrasal complexity. Of these four, only one component index (possessives) demonstrated significant linear trends with time spent studying English. This trend was observed only in the Salsbury corpus, and there is some evidence to suggest that this trend may have been due to construct irrelevant factors (e.g., writing topic). The lack of a strong relationship between proficiency and fine-grained clausal complexity is unexpected in light of current theories of academic writing complexity development (Biber et al., 2011). Biber et al. hypothesize that writers will move from using features of conversation (e.g., finite complement clauses) to features of fiction (e.g., possessives as pre-modifiers), and finally to features of academic writing (e.g., phrasal elaboration). Based on this hypothesized developmental sequence, we would expect to see a small number of phrasal complexity features near the beginning of each longitudinal corpus, moving to writing that is characterized by these features near the end. These trends are not evident in either corpus, suggesting that either the Biber et al. developmental sequence is inaccurate, the TAASSC components are not fine-grained enough to capture the features in the sequence adequately, or the development in the Verspoor and Salsbury corpora fall outside the sequence. Future research is warranted here.

### **5.3.4 Research Question 4b: Syntactic sophistication**

The results indicate a significant linear trend with a large effect for the verb-VAC component in both the Salsbury and the Verspoor corpora. The direction of the trend suggests that as individuals spend time studying English, they tend to use less frequent verb-VAC combinations. This trend supports usage-based perspectives on language learning (Behrens, 2009; Ellis, 2002a; Tomasello, 2003). Verb-VAC combinations that are more frequent in the

input seem to be learned (and used) earlier, while less frequent verb-VAC combinations seem to be learned (and used) later. A significant trend was also observed for the frequency component in the Verspoor corpus, and similarly a trend with a meaningful effect size (but that did not reach significance, likely due to the small sample) was observed in the Salisbury corpus. The direction of the trend suggested participants use less frequent items (e.g., main verb lemmas) as they spend time studying English. Additionally, in the Verspoor corpus, a significant linear trend with a large effect was observed for the diversity and frequency component. The positive trend suggests that participants may have learned more VACs, and therefore may have used a wider range of VACs as they spent time studying English. This trend was not evident in the Salisbury corpus, and therefore more research is needed before they results can be generalized. Overall, the results provide supporting evidence for usage-based perspectives.

### **5.3.5 Research Question 5b: All TAASSC indices**

Mean length of T-unit and the verb-VAC frequency component demonstrate the largest linear trends across the two corpora that varied by educational context, age of learners, and register. As individuals spent time studying English (and become more proficient) they tend to write T-units that are longer, and also use verb-VAC combinations that are less frequent. These results support longstanding theories of writing development (Ortega, 2003; Wolfe-Quintero et al., 1998), which suggest that as language learners develop, they will produce more complex language. These results also support the application of usage-based perspectives on language learning, which suggest that frequent constructions in the input will be learned earlier/more easily, to writing development. See Table 5.20 for the ten strongest effect sizes found in the statistical analyses. Other findings, which are outlined above also generally support this finding, but were specific to one of the two corpora.



*Table 5.20 The ten strongest effect sizes across the two longitudinal studies*

Index	Corpus	<i>p</i>	$\eta^2_p$
mean length of T-unit	Salsbury	< .001	0.960
verb-VAC frequency	Verspoor	< .001	0.855
verb-VAC frequency	Salsbury	.010	0.768
T-units per sentence	Salsbury	.023	0.676
mean length of T-unit	Verspoor	.005	0.640
possessives	Salsbury	.035	0.624
diversity and frequency	Verspoor	.014	0.551
frequency	Verspoor	.019	0.518
complex nominals per clause	Salsbury	0.078	0.495
frequency	Salsbury	0.131	0.394

### 5.3.6 Limitations

This study had two main limitations that should be considered when interpreting the results. The first limitation concerns writing topic. In the Salsbury corpus, English free writes were collected from participants. Near the beginning of the year of study, most participants wrote free writes about their lives in a new place (that is, they did indeed write free writes in English). At various points during the year, however, it was clear that the participants occasionally practiced writing argumentative essays (ostensibly based on required work in their writing courses), which may have affected the results (i.e., some observed differences in syntactic features may be due to genre/topic effects). Additionally, in the Verspoor corpus the six writing prompts were not counterbalanced. The topics were relatively similar over the two-year period, but may have increased in task complexity, potentially affecting the results.

The second limitation concerns the analyses conducted. This study sought to find linear relationships between particular linguistic variables and language development over time. This approach, which is well represented in applied linguistics research, has recently been problematized (e.g., Larsen-Freeman & Cameron, 2008; Larsen-Freeman, 1997). An overarching assumption of linear approaches is that language development with regard to such

linguistic variables (e.g., complex or infrequent syntactic/lexicogrammatical structures) is linear. Another assumption that tends to be made in linear approaches is that the development and/or use of particular linguistic features occurs independently of other features (both linguistic and otherwise). While significant linear trends with large effect sizes were observed with regard to some syntactic variables (e.g., verb-VAC frequency), the results may suppress the variability that exists between participants. Thus, a useful future approach would be to adopt a complex adaptive systems perspective (Larsen-Freeman & Cameron, 2008; Larsen-Freeman, 1997). Such a perspective may better explain both individual variability in syntactic development and the factors which contribute to this variability.

A third limitation is the size of the corpora explored. Each learner corpus was quite small. The Salisbury corpus includes writings from six participants, while the Verspoor corpus includes essays from nine students. As such, the generalizations that can be made about language learning in terms of syntactic complexity and sophistication may be limited.

### **5.3.7 Future directions**

Future research should represent principled replications of the analyses conducted in this study in other writing and learning contexts to determine how stable the findings are. Additionally, every effort should be made to control for construct irrelevant variables (such as writing topic). Furthermore, the principled use of micro-features (as opposed to component scores) may be a rich area for investigation to determine the precise structures that emerge as students write longer T-units.

## **6 Conclusion and Outlook**

This goal of this dissertation project was to supplement and refine our understanding of syntactic development in writing by developing and testing new indices of syntactic development

following recent discussions in the field. To this end, fine grained clausal and phrasal indices were developed based on recent work the nature of syntactic complexity (Biber et al., 2011; Norris & Ortega, 2009) along with frequency-based indices that draw on usage-based perspectives (Ellis, 2002a; Goldberg, 1995; Tomasello, 2003). These indices, in addition to the traditional indices of syntactic complexity were used to analyze syntactic development across TOEFL writing proficiency scores and two longitudinal corpora. A number of developmental trends were observed, some of which were stable across all datasets, but others were restricted to only one or two of the datasets. A summary of the outcomes and findings of this dissertation is provided below.

### **6.1 The Tool for the Automatic Analysis of Syntactic Sophistication and Complexity**

An important outcome of this dissertation is the release of the Tool for the Automatic Analysis of Syntactic Sophistication and Complexity (TAASSC). Chapter 3 described the indices included in TAASSC, which comprise the 14 indices measured by Lu's (2010, 2011) Syntactic Complexity analyzer, 31 fine-grained indices of clausal complexity, 132 fine-grained indices of phrasal complexity, 190 usage-based indices of syntactic sophistication, and nine component indices. These indices are based on and draw heavily from previous research (e.g., Biber et al., 2011; Bulté & Housen, 2012; Ellis & Ferreira-Junior, 2009b; Gries et al., 2005; Norris & Ortega, 2009; Wolfe-Quintero et al., 1998), and their implementation is possible due to recent advances in natural language processing (Chen & Manning, 2014; de Marneffe et al., 2006). TAASSC requires no programming knowledge, works on a variety of operating systems, and is freely available at <http://www.kristopherkyle.com/taassc.html>. It is hoped that TAASSC will benefit the research community and further work in the area of syntactic development.

TAASSC may be particularly useful for researchers testing theories of language development generally and writing development specifically (e.g., Biber et al., 2011; Ellis, 2002a; Norris & Ortega, 2009). TAASSC is particularly well suited for learner corpus research (e.g., Granger et al., 2009; Granger & Leech, 2014), in that large collections of learner texts can be analyzed with regard to syntactic features in a short amount of time and at no cost. TAASSC indices may also be of particular use in language assessment contexts. For example, TAASSC indices of syntactic complexity and sophistication may increase construct coverage of existing automatic essay scoring systems (e.g., Attali & Burstein, 2006). TAASSC indices could also be used in conjunction with other freely available text analysis tools such as the tool for the automatic analysis of lexical sophistication (TAALES) (Kyle & Crossley, 2015) and the tool for the automatic analysis of cohesion (TAACO) (Crossley, Kyle, & McNamara, 2016, 2015) to create new essay scoring models. In addition to modelling syntactic development directly, TAASSC indices may also prove useful in analyzing the effects of writing task types on test-taker production (e.g., Ramineni, Trapani, Williamson, Davey, & Bridgeman, 2012; Weiwei Yang, Lu, & Weigle, 2015). Furthermore, TAASSC indices may be beneficial in rater cognition studies (e.g., Eckes, 2008, 2012) to compare survey-based rater bias models with textual features. TAASSC indices may also prove useful in intelligent tutoring systems (ITS) such as W-PAL (Crossley, Allen, & McNamara, in press) by providing focused syntactic feedback. TAASSC indices may also be useful to corpus linguists and/or sociolinguists interested in studying diachronic language change (e.g., Kulick, Kroch, & Santorini, 2014; Nevalainen, 2013) and/or synchronic language variation (Biber & Conrad, 2014; e.g., Friginal & Hardy, 2013; Grieve, Biber, Friginal, & Nekrasova, 2010). TAASSC indices may also be useful for controlling for syntactic differences in language stimuli for psychological and psycholinguistic studies

(Harley, 2013). These are but a few examples of the applications of TAASSC indices. In short, TAASSC indices may be useful for anyone interested in syntactic features of written texts. In this project, TAASSC was used to explore the relationship between syntactic features and language development. A summary of these findings can be found below.

## 6.2 Summary of Findings

### 6.2.1 Research Question 1: Syntactic complexity analyzer indices

*What is the relationship between the Syntactic Complexity Analyzer indices and*

- a. holistic scores of writing proficiency?*
- b. longitudinal writing development?*

The results indicated that there was a significant (but weak) positive relationship between mean length of clause and holistic writing scores of writing proficiency, suggesting that higher rated essays tend to include longer clauses. This aligns with previous studies, such as Lu (2010, 2011), who found that mean length of clause increased across university levels. This relationship, however, was significantly weaker than the relationship between holistic scores of writing proficiency and indices of fine-grained phrasal complexity and indices of syntactic sophistication. Furthermore, the relationship between mean length of clause and writing development was not observed in either of the longitudinal corpora, suggesting that the predictive nature of the mean length of clause index is not independent of tasks such as high-stakes timed writing assignments, low-stakes timed writing assignments, and freewrites.

The longitudinal results indicated a significant positive relationship with a large effect between mean length of T-unit and time in both corpora. This suggests that as individuals spend time studying English (and become more proficient writers), they tend to write longer T-units. By and large, this aligns with previous findings (Lu, 2011; Ortega, 2003; Wolfe-Quintero et al.,

1998). At least two questions remain with regard to these results, however. First, based solely on the mean length of T-unit index, it is unclear what syntactic structures are being produced to increase T-unit length. The second regards the extent to which the mean length of T-unit index is predictive across writing tasks and contexts, given the lack of a relationship between mean length of T-unit and holistic scores of writing proficiency.

### **6.2.2 Research Question 2: Fine-grained clausal complexity indices**

*What is the relationship between fine-grained indices of clausal complexity and*

*a. holistic scores of writing proficiency?*

*b. longitudinal writing development?*

The results indicated that there was a significant (but weak) relationship between fine-grained indices of clausal complexity and holistic scores of writing proficiency. The results suggest that higher proficiency essays tend to include more non-finite clauses (such as infinitive and gerund clauses) and a wider range of dependents per clause. The relationship between fine-grained indices of clausal complexity and holistic scores of writing proficiency was significantly weaker than the relationship between writing proficiency and fine-grained indices of phrasal complexity. This finding generally supports Biber et al.'s (2011) assertion that phrasal complexity (not clausal complexity) is a feature of academic writing. The relationship between writing proficiency and fine-grained indices of clausal complexity was also significantly weaker than the relationship between writing proficiency and indices of syntactic sophistication. This finding generally supports usage-based theories of language development (e.g., Ellis, 2002), which posit that frequency (and not complexity) is a key component of development.

The results between fine-grained indices of clausal complexity and longitudinal development were also weak. Two fine-grained indices of clausal complexity related to the use

of copular constructions (nominal complements per clause and adjective complements per clause) were included in the verb-VAC frequency component, which demonstrated a negative linear trend over time with a large effect. This suggests that as individuals spend time studying English (and become more proficient writers) they tend to use fewer copular constructions. This finding may be more closely related to sophistication than complexity however, in that copular constructions tend to be highly frequent in COCA. Following usage-based perspectives (Behrens, 2009; Ellis, 2002a; Tomasello, 2003), this finding would suggest that individuals learn copular constructions at early stages of development, and use them less heavily as they become more proficient and are more likely to use less frequent constructions.

Overall, only weak relationships were found between fine-grained indices of clausal complexity and writing development. These results support Biber et al.'s (2011) assertions that clausal complexity is not a feature of academic writing.

### **6.2.3 Research Question 3: Fine-grained phrasal complexity indices**

*What is the relationship between fine-grained indices of phrasal complexity and*

- a. holistic scores of writing proficiency?*
- b. longitudinal writing development?*

The results indicated that there was a significant relationship with a medium effect size between fine grained indices of phrasal complexity and holistic scores of writing proficiency. The results suggest that higher proficiency essays tend to include more dependents, and specifically more prepositions per object of the pronoun, a wider range of dependents per nominal subject and direct object, non-pronominal direct objects with more dependents, and more pronominal direct objects. These results generally support Biber et al.'s (2011) hypothesized developmental scale, which suggests that as individuals become more proficient,

their writing will be characterized by noun phrase complexity (which is a feature of academic writing).

The results from the longitudinal studies indicate that of the four TAASSC components that feature fine-grained indices of phrasal complexity, only one (the possessives component) demonstrated a significant linear trend with time. Furthermore, the possessives component only demonstrated a significant linear trend in the Salsbury corpus, suggesting that Biber et al.'s (2011) findings may only be applicable to holistic writing proficiency scores in timed, argumentative essays, but not to the EFL and ESL longitudinal corpora analyzed in this study. The longitudinal results generally suggest that Biber et al.'s (2011) hypothesized developmental scale may be inappropriate for the contexts and writing tasks represented (i.e., untimed, unstructured free writes by adult ESL learners and untimed, descriptive essays written by middle-school EFL students). The conflicting results between the TOEFL writing proficiency corpus and the longitudinal corpora warrant further research to determine the validity of Biber et al.'s proposed developmental scale across contexts.

#### **6.2.4 Research Question 4: Indices of syntactic sophistication**

*What is the relationship between usage-based indices of syntactic sophistication*

- a. holistic scores of writing proficiency?*
- b. longitudinal writing development?*

The results indicated that there was a significant relationship with a medium effect between indices of syntactic sophistication and holistic scores of writing proficiency. The results suggest that higher proficiency essays tend to include less frequent VACs, a higher VAC type-token ratio, and verb-VAC combinations that are more strongly associated. These findings suggest that individual first learn (and use) a small number of frequent VACs at early proficiency



levels and likely use a wide variety of verbs that may not always be appropriate. As learners develop, their cumulative language experiences allow them to learn (and use) less frequent VACs while also learning which verbs tend to fit with particular VACs. This interpretation of the results supports usage-based perspectives of language learning (Behrens, 2009; Ellis, 2002a; Tomasello, 2003) and suggest that a) usage-based perspectives are applicable to a wide range of VACs, b) usage-based perspectives apply to writing development, and c) indices of syntactic sophistication, which are based on usage-based perspectives, can be used to model essay scores.

Overall, the longitudinal results support the findings related to holistic essay scores of writing proficiency. The verb-VAC frequency component demonstrated a significant negative linear trend with a large effect in both longitudinal corpora. The results suggest that as individuals spend time learning English (and become more proficient) that they tend to use less frequent verb-VAC combinations, which supports usage-based perspectives. Other components related to syntactic sophistication also supported these trends, including the frequency component and the frequency and diversity component in the Verspoor corpus, but significant trends were not found for these components in the Salisbury corpus.

One point of departure between the TOEFL writing proficiency corpus and the longitudinal corpus with regard to indices of syntactic sophistication was the role of verb-VAC strength of association measures. In the TOEFL writing proficiency corpus, these indices played an important role, while in the longitudinal corpora no significant and/or meaningful trend was observed with regard to the association strength component. One explanation for this may be that there is no overlap in the verb-VAC strength of association predictor indices in the TOEFL study and the indices included in the association strength component, leading to varying results. Another explanation for this may be a difference in proficiency levels between the TOEFL

writing proficiency corpus and either longitudinal corpus. Individuals' verb-VAC combination sensitivities may not have reached a point at which they begin to use strongly associated verb-VAC combinations regularly. This is an area for future work.

### **6.2.5 Research Question 5: All TAASSC indices**

*What is the relationship between all syntactic development indices included in TAASSC and*

- a. holistic scores of writing proficiency?*
- b. longitudinal writing development?*

The results indicated that a significant predictor model with a medium effect included fine-grained indices of clausal complexity, fine-grained indices of phrasal complexity, and indices of syntactic sophistication. Of the 34.2% of the variance in holistic scores of writing proficiency explained by the model, the largest variance was explained by fine-grained indices of phrasal complexity (17.6%), followed closely by indices of syntactic sophistication (15.5%). Fine-grained indices of clausal complexity explained the least amount of the variance (1.0%), and no traditional indices of syntactic complexity were included in the model. These results, along with the cumulative results of the other TOEFL writing proficiency studies conducted as part of this dissertation, generally support both Biber et al.'s (2011) hypothesized developmental scale and usage-based perspectives on language learning. From the phrasal complexity perspective, the results suggest that as writers become more proficient, their writing is characterized by complex noun phrases, which is a feature of academic writing (Biber et al., 2011). From a usage-based perspective, the results suggest that individuals learn (and use) VACs that occur frequently in the input at earlier stages of proficiency, and as they become more proficient they learn (and use) less frequent VACs in addition to the frequent ones (e.g., Ellis, 2002a). The results also suggest that as learners become more proficient writers, they tend to

become more sensitive to the verbs that are strongly associated with particular VACs and use strongly associated verb-VAC combinations more often.

The longitudinal results generally support the TOEFL writing proficiency findings with regard to indices of syntactic sophistication, further supporting usage-based perspectives of language learning (Behrens, 2009; Ellis, 2002a; Tomasello, 2003). The longitudinal results diverge, however, with regard to both the traditional indices measured by the Syntactic Complexity Analyzer (Lu, 2010, 2011) and fine-grained indices of phrasal complexity. In both longitudinal corpora, mean length of T-unit demonstrated positive linear trends with strong effects. These results diverge from the TOEFL writing proficiency results, but generally align with the bulk of studies that have used the index to measure syntactic growth (Lu, 2010; Ortega, 2003; Wolfe-Quintero et al., 1998). It appears clear that as writers become more proficient, they tend to write longer T-units. Syntactic elaboration is not explicitly included as a TOEFL rubric descriptor, which may explain the lack of a relationship between T-unit length and holistic scores of writing proficiency. No linear relationship was observed between fine-grained indices of phrasal complexity and time, despite being the strong predictor of holistic writing proficiency scores. These results bear further investigation to determine why raters appear to value phrasal sophistication as an indicator of proficiency, but phrasal complexity development was not observed in either of the longitudinal datasets.

### **6.2.6 Summary of findings**

Across the cross-sectional (TOEFL independent essays) and longitudinal (Salsbury corpus and Verspoor corpus) datasets, both convergence and divergence was observed. The strongest and most constant finding across datasets was the relationship between indices of syntactic sophistication and language development. In all three datasets, verb-VAC combination

frequency demonstrated a negative relationship with language proficiency/development. As learners became more proficient writers/language users, then tended to use less frequent verb-VAC combinations. This finding generally supports usage-based theories of language development (e.g., Behrens, 2009; Ellis, 2002; Tomasello, 2003), and extends previous L2 usage-based findings in aural/oral modes (e.g., Ellis & Ferreira-Junior, 2009b) to writing development. Another strong finding, which was observed in both longitudinal datasets (but not in the cross-sectional TOEFL data), was the positive relationship between mean length of T-unit (MLTU) and language development. In both the Salsbury corpus and the Verspoor corpus, writers wrote longer T-units as they became more proficient in English. These longitudinal results support a number of previous cross-sectional and longitudinal studies (c.f., Knoch et al., 2014; e.g., Lu, 2011; Ortega, 2003).

Other results were dataset specific. Fine-grained indices of noun-phrase complexity, for example, were the strongest predictors of writing quality in the cross-sectional TOEFL independent essay dataset. TOEFL independent essays that included more noun-phrase elaboration (and in particular more dependents per object of the preposition) tended to earn higher scores. These results were not observed in either of the longitudinal corpora. Future research is warranted to explore the degree to which these differences are due to variables such as task type and writing context.

### **6.3 Contributions**

This dissertation project has two main contributions to the field of applied linguistics. The first contribution is that it has tested multiple theories of syntactic development both cross-sectionally and longitudinally. The results support usage-based theories of language acquisition (e.g., Behrens, 2009; Ellis, 2002a; Tomasello, 2003) with regard to the development of verb

argument constructions. In all three datasets, a negative relationship between language proficiency and verb-VAC combination frequency, suggesting that as learners experience more language input, they learn (and use) less frequent verb-VAC combinations. Additionally, some support was found for Biber et al.'s (2011) developmental scale in that phrasal complexity features were positively correlated with writing proficiency (in the cross-sectional TOEFL dataset), and clausal complexity features were not particularly predictive of writing proficiency.

The second contribution of this dissertation project is the development and release of the Tool for the Automatic Analysis of Syntactic Sophistication and Complexity (TAASSC). TAASSC is freely available, easy to use, and works on all major operating systems (Windows, Mac OSX, and Linux) making it accessible to a wide range of researchers. TAASSC allows for the replication of this study using any written dataset a researcher desires to use (provided texts are formatted in plain .txt files). TAASSC also includes frequency and strength of association norms for all of the verb-argument constructions in the Corpus of Contemporary American English (Davies, 2009), which may prove to be of particular interest to corpus linguists. Additionally, the release of TAASSC should enable developers of automatic scoring systems (AES) and automatic writing evaluation (AWE) to both increase construct coverage and provide more detailed writing feedback.

## **6.4 Implications**

The findings of this dissertation project have important implications for second language acquisition, writing assessment, and second language pedagogy.

### **6.4.1 Second language acquisition**

First, the findings support usage-based theories of language learning (e.g., Behrens, 2009; Ellis, 2002a; Tomasello, 2003), which suggest that frequency is the driving force in language

learning. Usage-based theories of language learning have previously been explored in L1 and L2 contexts with regard to aural/oral modes and with regard to a small set of verb-argument constructions. This study has extended these findings to a large set of VACs and to writing development. Second, the results also provide some support for Biber et al.'s (2011) proposed developmental scale, which suggests that as writers develop, they move from using features of oral communication (e.g., clausal subordination) to features of academic writing (e.g., phrasal complexity/elaboration).

#### **6.4.2 Writing assessment**

The findings also have important implications for writing assessment. In particular, the results suggest that rating scales should include descriptors related to lexico-grammatical language features. This is appropriate in light of the finding that a consistent relationship was observed between writing development/proficiency and lexico-grammatical features (i.e., verb-VAC frequency). Additionally, rating scales for academic writing tasks (i.e., TOEFL independent essays) should also include descriptors related to noun phrase complexity. This is appropriate in light of the finding that noun phrase complexity was the strongest predictor of holistic scores of writing proficiency with regard to TOEFL independent essays. Furthermore, the results suggest that including features such as noun phrase complexity indices and indices related to verb-VAC frequency and strength of association in automatic essay scoring systems may increase construct coverage.

#### **6.4.3 Second language pedagogy**

The findings also have tentative implications for second language pedagogy. First, the results support the notion that learners' sensitivity to input frequency goes beyond single vocabulary items (e.g., Ellis, 2002). It may be beneficial to teach verb-VAC combinations, both

explicitly and explicitly in addition to teaching vocabulary and grammar. A particularly helpful resource for such an approach is reported by Littlemore (2009), who suggested a number of practical ways to teach in a manner that is consistent with usage-based theories of language learning and cognitive grammar. Additionally, academic writing pedagogy may benefit from a focus on noun-phrase elaboration, which has been shown to be a feature of both advanced academic writing (Biber et al., 2011) and high scoring TOEFL independent essays in this project.

## **6.5 Limitations**

As with most studies, the studies that comprise this dissertation have a number of limitations. First, the samples sizes (especially in the longitudinal corpora) were quite small, which may limit the generalizations that can be made. Another important limitation of the longitudinal studies was the (lack of) consistency in writing prompts across collection points. In the Salisbury corpus, participants wrote “free-writes”, which may have included writing samples that represent a range of registers/genres. Additionally, the writing tasks in the Verspoor corpus were not counterbalanced (though they were on similar topics), which may have affected the linguistic features produced in each set of essays.

Another limitation that could be addressed in future studies is the reference corpus that was used as a proxy for linguistic input. While the Corpus of Contemporary American English (COCA; Davies, 2009) may be representative of an American, adult L1 English user’s language experiences, it is likely not representative of the varied input to which a language learner is exposed. A fruitful exercise may be to first determine a systematic method for modelling the types of input a typical language learner receives (if a “typical” language learner exists). A second step would then be to collect such a corpus and use it to obtain the types of frequency norms obtained from COCA for this dissertation.

Furthermore, the definition of a verb argument construction was largely determined based on the features analyzed by the Stanford Neural Network Dependency Parser (Chen & Manning, 2014). While this approach was straightforward and likely reduced error rates, it is possible that distinctions between VACs were made that were not appropriate. For example, a VAC (e.g., *subject-verb-object*) that includes a subordinating conjunction (i.e., *because*) was counted as a separate VAC type from its non-subordinated counterpart. Future research may work to problematize and improve upon the definition of VACs used in this study. One such approach would be to use a resource such as the grammar patterns found in Hunston and Francis (2000). Another potentially useful approach would be to determine a verb similarity threshold for combining two VACs with similar verb occupancy profiles. If, for example, subordinated and un-subordinated *subject-verb-object* constructions included similar verb frequency profiles, it may be appropriate to combine them.

Additionally, the use of computational tools for L2 language analysis has some limitations. While computational tools have a number of advantages for such a task, they are not without fault. Studies have shown that the Stanford Neural Network Dependency Parser, which was used in this dissertation, achieves approximately 90% labeling accuracy with well-formatted and edited texts (such as newspaper and magazine articles; Chen & Manning, 2014). While we are fairly confident in the results of the study, the accuracy of the parser is likely less accurate with learner texts, which introduces a certain amount of noise.

## 6.6 Outlook

Over the past twenty years, natural language processing technology has steadily advanced. Although some applied linguists have been involved with and leveraged these advancements (Biber, 1988; Lu, 2011; MacWhinney & Snow, 1990; McNamara et al., 2010;



O'Donnell & Ellis, 2010), by and large, second language acquisition (SLA) researchers have not done so. Computational methods in general, and syntactic parsers in particular are not perfect, but they have been improving at a consistently rapid pace (Chen & Manning, 2014; de Marneffe et al., 2006; Klein & Manning, 2003). This improvement has led to analysis techniques that rival (and in some cases surpass) the reliability of humans (Attali & Burstein, 2006) while using a fraction of the resources (Higgins et al., 2011; Lu, 2010). It is hoped that second language researchers will increasingly explore the degree to which computational analyses may (or may not) aid in addressing important questions in the field. By problematizing and improving upon tools that already exist, second language researchers can help to mold (and create) tools that are designed specifically for the needs of such researchers.

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## APPENDICES

## Appendix A: TOEFL Independent Essay Rubric


**iBT/Next Generation TOEFL Test  
Integrated Writing Rubrics (Scoring Standards)**

Score	Task Description
5	A response at this level successfully selects the important information from the lecture and coherently and accurately presents this information in relation to the relevant information presented in the reading. The response is well organized, and occasional language errors that are present do not result in inaccurate or imprecise presentation of content or connections.
4	A response at this level is generally good in selecting the important information from the lecture and in coherently and accurately presenting this information in relation to the relevant information in the reading, but it may have minor omission, inaccuracy, vagueness, or imprecision of some content from the lecture or in connection to points made in the reading. A response is also scored at this level if it has more frequent or noticeable minor language errors, as long as such usage and grammatical structures do not result in anything more than an occasional lapse of clarity or in the connection of ideas.
3	A response at this level contains some important information from the lecture and conveys some relevant connection to the reading, but it is marked by one or more of the following: <ul style="list-style-type: none"> <li>• Although the overall response is definitely oriented to the task, it conveys only vague, global, unclear, or somewhat imprecise connection of the points made in the lecture to points made in the reading.</li> <li>• The response may omit one major key point made in the lecture.</li> <li>• Some key points made in the lecture or the reading, or connections between the two, may be incomplete, inaccurate, or imprecise.</li> <li>• Errors of usage and/or grammar may be more frequent or may result in noticeably vague expressions or obscured meanings in conveying ideas and connections.</li> </ul>
2	A response at this level contains some relevant information from the lecture, but is marked by significant language difficulties or by significant omission or inaccuracy of important ideas from the lecture or in the connections between the lecture and the reading; a response at this level is marked by one or more of the following: <ul style="list-style-type: none"> <li>• The response significantly misrepresents or completely omits the overall connection between the lecture and the reading.</li> <li>• The response significantly omits or significantly misrepresents important points made in the lecture.</li> <li>• The response contains language errors or expressions that largely obscure connections or meaning at key junctures, or that would likely obscure understanding of key ideas for a reader not already familiar with the reading and the lecture.</li> </ul>
1	A response at this level is marked by one or more of the following: <ul style="list-style-type: none"> <li>• The response provides little or no meaningful or relevant coherent content from the lecture.</li> <li>• The language level of the response is so low that it is difficult to derive meaning.</li> </ul>
0	A response at this level merely copies sentences from the reading, rejects the topic or is otherwise not connected to the topic, is written in a foreign language, consists of keystroke characters, or is blank.