
Methods and procedures for a Systemic Functional Linguistic Analysis: An investigation into clause complexing relations

1297-5
Sridevi Srinivass
Faculty of Languages and Linguistics
University of Malaya

Abstract

This paper outlines a methodology which is consistent with a heuristic-grounded theory- document analysis- qualitative approach (Patton, 1990, Creswell, 1994 & Halliday, 1996, Biber et al., 1998) that was employed in a recent cross disciplinary doctoral research. The study was an investigation into the linguistic resources that construct specialised knowledge in chemistry. The theoretical framework of systemic functional linguistics (SFL) outlined by Halliday and Matthiessen (2004 based in turn on Halliday (1994/1985)) was used as the main research tool. The system of taxis and logico semantic relations was demonstrated in relation to three analytical chemistry textbooks used at the undergraduate level in University of Malaya on the subject of chromatography (Rubinson & Rubinson, 1998, Skoog, et al., 2000 and Christian, 2004). The principal markers of taxis and logico-semantic relations were identified according to 57 coding categories remodeled after Halliday & Matthiessen's (2004) conceptualization of taxis and logico semantic resources in English.

The research methodology used in the study was not a set of procedures nor did it follow any hierarchy or priority in the procedures for obtaining linguistic description. Hence, this paper will attempt to show how theory was used maximally to account for linguistic description and provide the foundations for explorations. The mediation of the range of semantic phenomena is through the researcher herself rather than through any inventory, questionnaire or machine, e.g. a parser or coder. Hence, this paper will discuss how theoretical issues such as the coding decisions, interpretation of complex grammatical constructions and association patterns, overlapping categories and other indeterminacies were resolved using a manual, clause by clause analysis. The analysis of data involved the constant comparing of

instances of one category with another in an attempt to refine the patterns that emerge. This paper will attempt to demonstrate the research design in a stepwise fashion which reflects the various dimensions to the analysis. Finally, the potential of a heuristic-grounded theory-document analysis-qualitative approach for encoding experiential meaning is outlined.

Introduction

This study will identify, describe and explain the methods and procedures for data collection and grammatical analysis of text in a natural context of use from a systemic functional linguistic (SFL) perspective. The data for the study came from three analytical chemistry textbooks (Rubinson & Rubinson (1998), Skoog, et.al (2000) and Christian (2004)) for undergraduate use. Published literature providing detailed descriptions of the methods and procedures for cross-disciplinary research of this kind are rare. Hence, the significance of the current study is in outlining a methodology for research into linguistic analysis from an SFL point of view, particularly in the genre of the textbook. The current study draws on a qualitative approach that was employed in a recent cross disciplinary doctoral research (See Srinivass 2006a.) which attempted to uncover the role of the clause complex in English for encoding tertiary chemistry phenomena in the genre of the textbook. Published research reporting how the theoretical framework proposed by Halliday and Matthiessen (2004) on the system of the clause complex was adapted for use can be found in Srinivass (2006b) and Srinivass (2008).

Overview of data: Data Selection, Collection & Description

Whole textbook chapters from three analytical chemistry textbooks for undergraduate use were used to sample information on chromatography

Chromatography is the most common and powerful analytical technique used in analytical chemistry, organic chemistry, biochemistry and medicinal chemistry for achieving analytical separations. In fact, "all branches of chemistry draw on the ideas and techniques of analytical chemistry" and it is often termed as the "central science" (Skoog et al., 2000:3). Altogether 5 undergraduate chemistry textbooks were shortlisted. Rubinson & Rubinson (1998), Pavia et.al (1999), Rouessac & Rouessac (2000), Skoog, et.al (2000) and Christian (2004). Of the five books, only Rubinson & Rubinson (1998), Skoog, et.al (2000) and Christian (2004) were selected. Rouessac & Rouessac (2000) which was a translation from French

and Pavia et.al (1999) which was a laboratory textbook were not selected for the study as the issue of representativeness was deemed crucial. The three textbooks selected fulfilled the following protocol and as such were regarded as suitable models of written chemistry exposition.

- i. Genre: tertiary chemistry textbooks,
- ii. Medium: written,
- iii. Language: authentic English, not translated works,
- iv. Publication. fairly recently, 1998, 2000 and 2004,
- v. Organization. around textbook chapters,
- vi. Audience: for an undergraduate chemistry course, particularly students of medicine, biology; engineering environmental science, material science and other fields related to chemistry, and those working in the field, university students in the Faculty of Science;
- vii. Availability: university bookstore;
- viii. Representativeness. identified to be analytical expositions in the genre of analytical chemistry and
- ix. Coverage: fundamental, traditional and practical aspects of analytical chemistry

Table 1.1 provides an overall survey of the textbooks used in the study. A more detailed overview of the division of textbook chapters into topics and sub-topics is provided in the appendix of the larger study.

Table 1.1 Survey of the selected textbooks for analysis

Textbook A.
Authors Rubinson, Judith F & Rubinson, Kenneth A.
Year of Publication. 1998.
Title of book: Contemporary Chemical Analysis.
Publication. Prentice Hall
Place of Publication. New Jersey, U S.A.
Total number of Chapters. 16
Chapters used for the study:
(i) Chapter 13 Separations and Chromatography (pages 404 - 457) totalling 53 pages and
(ii) Chapter 14. Separations by Applied Voltage: Electro-separations (459 483) totalling 24 pages.
Textbook B

Authors: Skoog, Douglas A., West, Donald M, Holler, F James & Crouch, Stanley R.

Year of Publication:

Title of book:

Publication. Saunders College Publishing,

Place of Publication.

Number of Chapters.

Chapters used for the study:

- (i) Chapter 24 An Introduction to Analytical Separations (pages 638 666) totalling 28 pages,
- (ii) Chapter 25 Gas-Liquid and High-Performance Fluid Chromatography (pages 667 – 695) totalling 28 pages and
- (iii) Electrophoresis, (pages 700 – 718) totalling 18 pages.

Textbook C:

Author: , Gary D.

Year of publication.

Title of book:

Publication. John Wiley & Sons,

Place of publication.

Number of chapters. 26

Chapter used for the study:

- (i) Chapter 19 Chromatography (pages 555 – 573) totalling 18 pages
- (ii) 603) totalling 29 pages
- (iii) Liquid chromatography (pages 604 – 642) totalling 38 pages

All the three selected textbooks contained chapters on separation techniques which covered topics typically found in any standard undergraduate analytical chemistry textbook such as 'Separations and Chromatography', and Techniques'

organization of the textbook chapters, the chapters above covered sub-topics on chromatography techniques such as gas chromatography, performance liquid chromatography and electrophoresis among others. diversity did not pose any interference in the analytical method of the study

as the unit of analysis was the lexicogrammatical¹ the rest of the text.

The textbook chapters were labelled as A1, A2, and C3 corresponding to chapters 13, (Textbook B)

Table 1.2.

Table 1.2 Labelling of textbook chapters that were used as data for analysis

<i>Source</i>	<i>Textbook label</i>	<i>Data label</i>	<i>Topic</i>
Rubinson & Rubinson (1998)	Textbook A	Text A1 (Study 13)	Separations and Chromatography
		Text A2 (Study 14)	Separations by Applied Voltage: Electroseparations
Skoog, West et al. (2000)	Textbook B	Text B1 (Study 24)	An Introduction to Analytical Separations
		Text B2 (Study 25)	Gas-Liquid and High-Performance Liquid Chromatography
		Text B3 (Study 26)	Supercritical-fluid Chromatography, Capillary Electrophoresis, and Capillary Electrochromatography
Christian (2004)	Textbook C	Text C1 (Study 19)	Chromatography: Principles and theory
		Text C2 (Study 20)	Gas chromatography
		Text C3 (Study 21)	Liquid chromatography

General criteria for determining text boundaries

There are close parallels between Martin’s (1989) description of factual genres (Recount, Procedure, Description and Report) and the organization of doing science in the textbook chapters used for this study. The textbook, regarded as a macro-genre, combines the factual genres of procedures, procedural recount,

The data as a whole are structured procedural recounts, and explanations dependent on reporting co-text” (Derewianka, textbook, scientific ideas are expressed not just from the “running verbal text” (after Lemke,

of images (for e. macro-genres identified above. a collection of text but represents the language of chromatography or part of that language in the running verbal texts. the interactions between the running verbal text and its graphics (Lemke, 1998, Kress and van Leeuwen, 2001, Martin, 2000 & 2003) Therefore, an identification criteria which distinguishes running verbal texts from other modalities such as figures, tables, photographs, pictures, in-box texts and annotations as is typically found in any science textbook was set up to determine the text boundaries. consistently applied to prepare the texts for analysis. collection' (after Biber et al., 1998 12) done. The text is set off orthographically with all section and sub-section labelling retained in its original form, given enumeration for ease of reference.

The study excludes the following items from the analysis.

- Images/diagrams and the texts including them
- Quotations
- Parenthetical information (Orthographic sentences set of in parentheses)
- Photographs
- Mathematical equations which are not directly integrated into running verbal text
- Action boxes
- In box text
- Tables
- Illustratio
- Annotations on the margin
- End notes
- Review questions
- Questions and Problems
- Spreadsheet calculations
- Concept Reviews
- Key word explanations
- Summaries and exercises
- Additional Exercises
- Computer Exercises
- Suggestions for further reading
- Web works
- Appendixes
- Endpapers

Research design

The research is divided into 6 analytical stages as follows.

- Stage 1** Display of running verbal text as orthographic units
- Stage 2** Identification of unit of analysis: the division of orthographic units into ranking clauses
- Stage 3** Identification of dependency and interdependency relations in clause nexuses
- Stage 4** Identification of principal markers of taxis and logico-semantic relations
- Stage 5** Counting of paratactic and hypotactic links for various logico-semantic relations
- Stage 6** Identification of favoured logogenetic patterns

The complete analysis of all clauses for *logico-semantic* relations is presented in four APPENDICES in the larger study:

- i. APPENDIX A presents the complete clause complex analysis for *elaboration*, *extension* and *enhancement* as well as *projection* relations for the eight text book chapters, A1, A2, B1, B2, B3, C1, C2 and C3 of the study in tabular form.
- ii. APPENDIX B is an index summarizing all instances of *paratactic* and *hypotactic elaboration*, *extension* and *enhancement* as well as *projection* using 57 coding categories.
- iii. APPENDIX C summarises the number of clauses forming complexes, clauses forming simplexes and the total number of clauses analysed.
- iv. APPENDIX D provides the original textbook chapters used for the study

The text extract, Text A1 shown in Table 1.3 is an example of a running verbal text. The text extract will be used to exemplify the analysis of knowledge construction in chemistry through the grammatical resources of clause complexes in 6 stages identified in the subsections below

Table 1.3 Text extract from Text A1 (section 13.1 entitled “The Chromatography Experiment”)

Chromatography is the science and art of separating the components of materials from each other. Such separations are achieved using a wide variety of techniques, and the molecular differences upon which the separations are based are quite diverse. For example, molecules can be separated by their differences in molecular charge, molecular size, molecular mass, bond polarities, redox potential, ionization constants, and arrangements of bonds such as isomer structure or chirality. Not generally included in chromatography are separations that use electric fields to drive charged molecules so that they separate. These other methods fall under the class called **electroseparation** or **electromigration** and **electrophoresis**. You will find them described in Study 14.

A quote from Michael Tswett, the originator of contemporary chromatography,

In this quote, he uses the word **adsorbent**. This is a solid material to which molecules bind on the surface. A **chromatographic column** is illustrated in Figure 13.1. In this case, it is a tube packed with adsorbent through which flows a liquid which is called eluent. The analyte is placed at the top of the column and washed through with the liquid eluent. The compounds are said to be eluted. They are carried through the packed column by the flowing liquid. In this example, the eluent is petroleum ether, which is a low boiling point, organic solvent. Tswett's column was a vertical tube open at the top with the eluent driven under its own weight through the adsorbent. Tswett used his eyes as a detector since the compounds he separated were coloured, and he could detect the bands or zones of different materials by their colors. As the compounds separated, there were bands of color on his column from the numerous components in the sample. This experiment showed that chlorophyll is only one of many pigments found in plant leaves. Tswett's simple column has evolved into the contemporary equipment illustrated in Figure 13.2.

The text extract in Table 1.3 is prepared for use as demonstrated in Section 1.3.1

Stage 1 Display of running verbal text as orthographic units

The running verbal texts are retyped and displayed as a sequence of numbered clauses as shown in Table 1.4 on the following page according to their respective headings and sub-headings retained. The discourse structure of the texts was not altered. Each section and subsection always starts with a new number. Similar to Wignell's, Martin's and Eggin's (in Halliday & Martin, 1993) observation on geography text, the researcher found that technical terms in chemistry were explicitly marked orthographically, by being boldfaced. To preserve the authentic appearance of the texts, terms in boldface (or italics), for example, '**electroseparation**', '**electromigration**' and '**electrophoresis**', were left intact as shown in Table 1.4.

All clauses, whether ranking³ or simplex⁴, were given numbers. For example, the clauses in the text extract above are numbered [13.1/1] to [13.1/19]. Each number begins with 13.1 referring to subsection 13.1 entitled 'The Chromatography Experiment'. Numbers 1-19 after the oblique 1 refer to the sequence of the clause as they appear in the original textbook study. As mentioned before, all subsections are retained; therefore, a clause labelled [13.2/5] draws reference to subsection 13.2 entitled 'Nomenclature of Chromatographic Separations' and '5' refers to the fifth clause in that subsection. However, in instances where there was no section number in the original text or when the section was divided into sub-sub sections without numbers, the abbreviations of the titles will be used in the enumeration as the following example shows:

Parameters for Individual Bands	
Clause no	Ranking clause
13.4/PIB/1	The first parameter that was used to characterize a chromatogram is the column that elutes from the column between the injection of the sample and the maximum of the first peak that elutes.
13.4/PIB/2	As noted above, this volume is called the hold-up volume.

Clause 1 in this sub-section has the clause number [13.4/PIB/1], in which PIB refers to the title 'Parameters for Individual Bands'. The enumeration method illustrated above was found to be extremely useful and was consistently used to label all numbered sequences of clauses across the eight texts analysed.

Table 1.4 Display of running verbal text as orthographic units (section 13.1 from Text A1)

Chromatography is the science and art of separating the components of materials from each other
Such separations are achieved using a wide variety of techniques, and the molecular differences upon which the separations are based are quite diverse.
For example, molecules can be separated by their differences in molecular charge, molecular size, molecular mass, ionization constants, and arrangements or chirality
Not generally included in chromatography are separations that use electric fields to drive charged molecules so that they separate.
These other methods fall under the class called electroseparation or electromigration and electrophoresis .
You will find them described in Study 14.
A quote from Michael Tswett, the originator of contemporary chromatography, In this quote, he uses
This is a solid material to which molecules bind on the surface.
A chromatographic column is illustrated in Figure 13.1
In this case, liquid which is called eluent.
The analyte is placed at the top of the column and washed through with the liquid eluent.
The compounds are said to be eluted. They are carried through the packed column by the flowing liquid.
In this example, the eluent is petroleum ether, which is a low boiling point,
Tswett's column was a vertical tube open at the top with the eluent driven under its own weight through the adsorbent.
Tswett used his eyes as a detector since the compounds he separated were coloured, and he could detect materials by their colors.
As the compounds separated, from the numerous components in the sample.

This experiment showed that chlorophyll is only one of many pigments found in plant leaves.

Tswett's simple column has evolved into the contemporary equipment illustrated in Figure 13.2.

At this stage of the analysis, it can be seen that the text extract has 19 manually numbered orthographic units, as shown in Table 1.5 below. The next stage is the identification of the unit of analysis of the clause complex which is the ranking clause³

**Stage 2 Identification
units into ranking clauses**

The unit of analysis in this study is the clause complex, therefore the orthographic units as shown in Table 1.4 above are divided into *ranking clauses* (after Halliday & Matthiessen, 2004:323). Ranking clauses are clauses which have units functioning according to their rank as opposed to rankshifted⁴ or embedded ones. A clause complex analysis is carried out to distinguish between clauses forming complexes from those that do not. Table 1.5 displays the text as a numbered sequence of ranking clauses with each clause in a clause complex relation with another given a new ranking line. All instances of embedded clauses are typed in parentheses whether they occur in simplexes or complexes or in clauses initiating the complex or continuing the complex⁵. As mentioned before, terminology which appear in bold in the original text are retained.

Table 1.5 Display of text as a numbered sequence of simplexes and ranking clauses

Clause no	Ranking clause
13 1/1	Chromatography is the science and art of separating the components of materials from each other.
13 1/2	Such separations are achieved [[using a wide variety of techniques]], and the molecular differences [[upon which the separations are based]] are quite diverse.
13 1/3	For example, molecules can be separated by their differences in molecular charge, molecular size, molecular mass, bond polarities, redox potential, ionization constants, and arrangements of bonds such as isomer structure or chirality

13 1/4	Not generally included in chromatography are separations [[that use electric fields [[to drive charged molecules [[so that they separate]]]]].
13 1/5	These other methods fall under the class called electroseparation or electromigration and electrophoresis .
13 1/6	You will find them [[described in Study 14]].
13 1/7	A quote from Michael Tswett, originator of contemporary chromatography,
13.1	chromatography
13 1/9	In this quote, This is a solid material [[to which molecules bind on the surface]]
13 1/10	A chromatographic column is illustrated in Figure 13 1
13.1	In this case, flows a liquid which is called eluent]]
13 1/12	The analyte is placed at the top of the column and [Ø] washed through with the liquid eluent.
13.1/13	The compounds are said to be eluted: They are carried through the packed column by the flowing liquid.
13 1/14	In this example, which is a low boiling point, organic solvent.
13 1/15	Tswett's column was a vertical tube open at the top with the eluent [[driven under its own weight through the adsorbent]]
13 1/16	Tswett used his eyes as a detector since the compounds [[he separated]] were and he could detect the bands or zones of different materials by their colors.
13 1/17	As the compounds separated, there were bands of color on his column from the numerous components in the sample.
13 1/18	This experiment showed [[that chlorophyll is only one of many pigments [[found in plant leaves]]]]
13 1/19	Tswett's simple column has evolved into the contemporary equipment [[illustrated in Figure 13.2.]]
Table 1 5 shows that there are 6 clauses which form clause complexes which capture the dependency or interdependency relationships between	

adjacent clauses whose two options are parataxis and hypotaxis. They are [13 1/2],[13 1/12], [13 1/13], [13.1/4],[13.1

Stage 3 Identification of dependency and interdependency relations in clause nexuses

In Stage 3, interdependency relationships between their adjacent clauses whose two options are *parataxis* (clauses of equal status) unequal status) which are in a *hypotactic* or a dependent relationship with each other. Clauses which are in a *paratactic* relationship or which are of equal status are given numerals, 1, 2, A clause boundary is recognized whenever possible, thus allowing a clause complex relationship to be coded in terms of *parataxis* or *hypotaxis* as shown in Table 1.6 below

Table 1.6 Display of text as a numbered sequence of ranking clauses distinguished for dependency and interdependency relations

Clause no	Taxis	Ranking clause
13 1/1		Chromatography is the science and art of separating the components of materials from each other.
13 1/2	1	Such separations are achieved [[using a wide variety of techniques]],
	2	and the molecular differences [[upon which the separations are based]]
13.1		For example, molecules can be separated by their differences in molecular charge, molecular molecular mass, bond polarities, redox potential, ionization constants, and arrangements of bonds such as isomer structure or chirality
13 1/4		Not generally included in chromatography are separations [[that use electric fields [[to drive charged molecules [[so that they separate]]]]]]
13.1/		These other methods fall under the class called electroseparation or electromigration and electrophoresis

13 1/6			You will find them [[described in Study 14]].
13 1/7			A quote from Michael Tswett, the originator of contemporary chromatography, will be used to introduce the concept of chromatography
13.1/8			In this quote, he uses the word adsorbent.
13.1/9			This is a solid material [[to which molecules bind on the surface]]
13.1/10			A chromatographic column is illustrated in Figure 13.1.
13 1/11			In this case, it is a tube packed with adsorbent [[through which flows a liquid which is called eluent]]
13 1/12	1		The analyte is placed at the top of the column
	2		and [☉] washed through with the liquid eluent.
13 1/13	1		The compounds are said to be eluted.
	2		They are carried through the packed column by the flowing liquid.
13 1/14	α		In this example, the eluent is petroleum ether,
	β		which is a low boiling point, organic solvent.
13 1/15			Tswett's column was a vertical tube open at the top with the eluent [[driven under its own weight through the adsorbent]]
13 1/16	1	α	Tswett used his eyes as a detector
		β	since the compounds [[he separated]] were coloured,
	2		and he could detect the bands or zones of different materials by their colors.
13.1/17	β		As the compounds separated,
	α		there were bands of color on his column from the numerous components in the sample.
13 1/18			This experiment showed [[that chlorophyll is only one of many pigments [[found in plant leaves]]]]
13 1/19			Tswett's simple column has evolved into the contemporary equipment [[illustrated in Figure 13.2.]]

Table 1 6 above shows that there are 4 *paratactic* clauses and 3 *hypotactic* ones. Further analysis is carried out in stage 4

Stage 4 Identification of principal markers of taxis and logico-semantic relations

Traditional notating conventions in systemic theory are used for the identification of the principal markers of taxis⁶ and the broad categories of *logico-semantic* relations⁷. Numerals are used to show clauses which are co-ordinated or in apposition. The '=' sign refers to *elaboration*, the '+' sign, to *extension*, the 'x' sign, to *enhancement* and the ']' sign to *projected idea*.

For the analysis of more delicate categories of *taxis* and *logico-semantic* relations, 57 coding categories and their respective notations were remodelled after Halliday & Matthiessen's (2004) categorization of clause complexing resources in English. Due to space constraints they are not shown in the current study but are shown in the larger study (See Srinivass 2006a.)

Table 1.7 below displays the same text as a sequence of numbered clauses showing both the syntactic structures as well as the kind of *logico-semantic* relations formed. Clauses forming straightforward complexes may be distinguished from those forming longer and structurally more complex ones through the identification of the logical structure of the *nexus*. The columns on the left show the structural delicacy of the clauses whether the clause complex is made up of only one complex or there are any sub-complexes made. The first row of any clause nexus is for the initiating clause in a *paratactic* relation and for the dominant clause in a *hypotactic* relation. Any additional row indicates a new *logico-semantic* relation whether it is the same type of relation as the previous one or different. The more rows there are, the more the number of *logico-semantic* relations. The table also includes columns on the right hand side. The four columns on the right hand side show the kind of *logico-semantic* relation made in both the system for *expanding* a clause (*elaboration*, *extension* and *enhancement*) as well as for *projecting* a clause (*mental and verbal projection*). The analysis of clauses for *taxis* and *logico-semantic* relations together contribute to the logical representations of univariate⁸ structures. For example, the systemic selection and structural realization of clause 13.1/2 may be represented as 1^+2. The equation is read as *Clause 1 is in a paratactic extension relation with Clause 2*.

Table 1.7 Display of text as a numbered sequence of taxis and logico-semantic relations

Clause no	Taxis	Ranking clause	Elaboration	Extension	Enhancement
13.1/1		Chromato-graphy is the science and art of separating the components of materials from each other.			
13.1/2	1	Such separations are achieved [[using a wide variety of techniques]],			
	+2	and the molecular differences [[upon which the separations are based]] are quite diverse.		ext/para/ add/ positive	
13.1/3		For example, molecules can be separated by their differences in molecular charge, molecular size, molecular mass, bond polarities, redox potential, ionization constants, and arrangements of bonds such as isomer structure or chirality.			
13.1/4		Not generally included in chromatography are separations [[that use electric fields [[to drive charged molecules [[so that they separate]]]]].			
13.1/5		These other methods fall under the class called electro-separation or electro-migration and electrophoresis .			
13.1/6		You will find them [[described in Study 14]].			

13.1/7			A quote from Michael Tswett, the originator of contemporary chromatography, will be used to introduce the concept of chromatography.			
13.1/8			In this quote, he uses the word adsorbent.			
13.1/9			This is a solid material [[to which molecules bind on the surface]].			
13.1/10			A chromatographic column is illustrated in Figure 13.1.			
13.1/11			In this case, it is a tube packed with adsorbent [[through which flows a liquid which is called eluent]].			
13.1/12	1		The analyte is placed at the top of the column			
		+2	and [Ø] washed through with the liquid eluent.			ext/para/ add/ positive (ellipsed subj)
13.1/13	1		The compounds are said to be eluted:			
		=2	They are carried through the packed column by the flowing liquid.			ela/para/ exp/appo
13.1/14	α		In this example, the eluent is petroleum ether,			
		=β	which is a low boiling point, organic solvent.			ela/hyp/ NDRC/ fin
13.1/15			Tswett's column was a vertical tube open at the top with the eluent [[driven under its own weight through the adsorbent]].			
13.1/16	1	α	Tswett used his eyes as a detector			
		xβ	since the compounds [[he separated]] were coloured,			enh/hyp/caus- cond/cause/ reason/fin

	+2		and he could detect the bands or zones of different materials by their colors.		ext/para/ add/ positive	
13.1/17	xβ		As the compounds <u>separated</u> ,			enh/hyp/ temp/same time/extent/ fin
	α		there were bands of color on his column from the numerous components in the sample.			
13 1/18			This experiment showed [[that chlorophyll is only one of many pigments [[found in plant leaves]]]]			
13 1/19			Tswett's simple column has evolved into the contemporary equipment [[illustrated in Figure 13.2.]]			

Legend:

ext/para/add/positive:

ext/para/add/ positive(ellipsed subj)

type relation with ellipsed subject

ela/para/exp/appo Paratactic elaboration exposition of the appositive

type rel

ela/hyp/ NDRC/ fin.

relative clause type relation

enh/hyp/caus-cond/cause/reason/fin.

finite causal-conditional reason type relation

enh/hyp/temp/same time/extent/

temporal same time extent type relation

In the current study, relation, finites and predicators⁹ connectors¹⁰ are in bold. marker signaling a *paratactic* relation is the *conjunction* 'and' and the *finite* is 'are' As mentioned before,

placed in double square brackets, for example, ‘[[using a wide variety of techniques]]’ in clause [13 1/2]. All instances of ellipsis¹¹ are noted by the symbol, Ø, for example clause [13 1/12]

Interpretation of taxis

The analysis of clause complexes presented in Table 1.7 above shows that the text extract has a mixture of *parataxis* and *hypotaxis* relations. This shows that chemistry texts contain both types of interdependency relation between clauses *parataxis* and *hypotaxis* which alternate across the text span. Clause nexuses may contain more than one type of *taxis* or *logico-semantic* relation or both.

Stage 2 already analysed the extract as having 19 clauses with 6 ranking clauses and Stage 3 already analysed the text as having 4 *paratactic* clauses and 3 *hypotactic* ones. Stage 4 identified the principal markers and *logico-semantic* relations. Further interpretations are as follows.

The text extract is examined for its systemic selections and structural realizations. Following Eggins (2004:285), the structural realization of the clause nexuses may be described in terms of “parts per structure” It was found that clauses [13 1/2], [13 1/12], [13 1/13], [13 1/14] and [13 1/17] have one part per structure each. Clauses [13 1/2], [13 1/12], [13 1/13] make single *paratactic* links while clauses [13 1/14] and [13 1/17] make single *hypotactic* links. Only clause [13.1/16] Clause [13.1/16] is a multi clause complex made up of a primary *paratactic* relation in which the initiating clause makes a sub-complex of a *hypotactic* relation.

Interpretation of logico-semantic relations

Logico-semantic relations are found in single relations as well as in sub-complexes. Clauses [13 1/2] and [13 1/12] are *paratactic additive positive* clauses marked by the conjunction ‘and’, clause [13 1/13] is a *paratactic elaboration* clause signalled by a colon, [13 1/14] is a *finite hypotactic NDRC elaborating* clause marked by the relative pronoun ‘which’, and [13 1/17] is a *finite hypotactic temporal same time enhancing* clause in thematic beta position, marked by the conjunction ‘as’ All these clauses form single relationships except for clause [13 1/16], which is an example of a multi clause complex as noted above.

Clauses [13 1/16] has a *paratactic additive* clause in the primary structure, marked by the conjunction ‘and’ and a *hypotactic causal-conditional reason* clause marked by the conjunction ‘since’ in the sub-

complex of the initiating clause. To elaborate, the primary semantic relationship is a *paratactic extension* between 'Tswett used his eyes as a detector' and 'and he could detect the bands or zones of different materials by their colors.' The secondary relationship is between the main clause, 'Tswett used his eyes as a detector' forming a *hypotactic enhancing* sub-complex with 'since the compounds [[he separated]] were coloured.' The logical structure may be represented as follows. 1 ($\alpha \wedge x\beta$)
 $\wedge +2$

This equation is read as *Clause 1 is in a relation of paratactic extension with Clause 2 and Clause 1 is also expanded hypotactically through a relation of enhancement*

Stage 5 Counting of paratactic and hypotactic links for various logico-semantic relations

The instances for each coding category are shown in APPENDIX B of the larger study *Paratactic and hypotactic links* as well as the number of occurrences of each type of *logico-semantic* relation are counted based on the tables provided in APPENDIX B of the larger study to see the semantic variation in all the texts analysed. Besides enabling a count of the semantic variation, the tabulation of the instances of the occurrences facilitates the researcher to keep track of any errors made and to correct them. Next, the percentage of distribution of the systemic choices of *taxis* and *logico-semantic* relations were calculated manually based on a simple mathematical calculation principle.

For example, to calculate the number of *paratactic exposition* relations (ela/para/exp/appo) across all eight texts, the following is done:

number of occurrences of paratactic
exposition relations across all eight
texts

x 100

number of both paratactic and hypotactic
elaboration relations in all eight
texts

$$\begin{aligned} &= x/y \times 100 \\ &= 86/309 \times 100 \\ &= 27.83\% \end{aligned}$$

Likewise, to calculate the total number of *elaborations* across all eight texts,

number of elaboration relations
(drawn from table xxx below)

$$\text{_____} \times 100 = z\%$$

number of clauses complexes
(expansion + projection)

$$\begin{aligned} &= 309 / (\text{elaboration} + \text{extension} + \text{enhancement}) \times \\ &= 309 / (309 + X + Y) \\ &= Z\% \end{aligned}$$

This simple calculation principle is used each time a percentage of a particular occurrence of *taxis* or semantic relation is sought. used above draw on the tables from APPENDIX B of the larger study

Stage 6 Identification of favoured logogenetic patterns or logical structures

The analysis of clause complex relations in the text extract above shows how the strategy for forming clause complex relations guide the local development of text in the construction of knowledge in chemistry. While the analysis of the internal structure of clause nexuses are confined to their own internal organization, of text, and the whole of the texts as is done in this study, point towards an indication of the favoured *logogenetic* or *tactic* patterns in the construal of knowledge in chemistry.

The findings reveal that both *parataxis* and *hypotaxis* intersect to define the system of *logico-semantic* relations. Table 1.8 shows the various kinds of relations found in the text analysed. The for forming clause complex relations is the single relation of a *paratactic*

complex 1^+2 (two instances),
relations,
clause complex, as in 13 1/16,

Table 1.8 The logical structures of clause complex relations found in the text extract analysed

Clauses forming complexes from the text extract (section 13 1, Text A1)	Logical structure
13 1/2	1^+2
13 1/12	1^+2
13 1/13	$1^=2$
13 1/14	$\alpha^=\beta$
13 1/16	$1(a^xb)$
13 1/17	$x\beta^{\alpha}$

Discussion and Conclusion

The current study has attempted to provide a systemic account of how knowledge is constructed in the genre of tertiary chemistry textbooks. particular, resource for the construal of knowledge. The current study limits itself to a single subject area, textbook chapters used at the undergraduate level in the University of Malaya.

It must be noted that in the rich tradition of SFL, Halliday's pioneering work (1961), not a set of procedures nor does it follow any hierarchy or priority in the procedures for obtaining linguistic description, rather the theory is used maximally to account for linguistic description as the emphasis is in the theory rather than the methodology. Linguistic description. The methodology used is also consistent with a heuristic- grounded theory-document analysis- qualitative approach which is derived from the theory itself (Patton, 1996, was carried out. phenomena is through the researcher herself rather than through any inventory, questionnaire or machine, e.g. a systemic parser or coder

Qualitative findings are presented together with quantitative data to facilitate interpretations of the instances and to gain insight on their extent of use in chemistry. The analysis of data involved the constant comparing of instances of one category of clause complexing relations with another in an attempt to "saturate" (after Creswell, 1994:156) the category in order to refine the patterns that emerge.

The current study also considers Sinclair's (1992:6) suggestion that while "it is impossible to study patterned data without some theory," it is also important that in the course of "prioritising some patterns" others are not obscured. Hence, the current study used 57 coding categories in order to obtain a more comprehensive picture.

Perhaps Halliday's view, though expressed a long time ago, best summarizes the kind of approach just described. "The linguist makes use of all he knows and there is no priority of dependence among the various parts of the description" (Halliday 1961:250). Nevertheless, this study has attempted to outline the research design in a stepwise fashion which reflects the various dimensions to the analysis.

In view of the above, computer packages for the analysis of clauses such as RSTTOOL (markup tool for Rhetorical Structure Theory) or computer programmes specially designed and developed for text analyses were not used. The reason is that the strategy of enquiry undertaken in this study involved analyzing complex grammatical constructions and complex association patterns, and readymade computer programmes are not designed for a thorough clause complex analysis as that undertaken in the study. There were various coding decisions to be weighed and considered and there were indeterminacies to be resolved concerning overlapping categories. The analytical issue was that the same principal markers may have different semantic realizations. Instances of nested constituents and embeddings make natural language intricate. In order to produce more accurate analyses and overcome analytical problems, statements of theory are continually assessed and the theoretical categories are further refined and developed in the course of the research. The principal markers and coding categories used in the analysis serve as a guide to conceptualise the logical content of chemistry. However the current study does not discount the fact that future research may use a concordance to make straightforward lexicogrammatical patterns more easily available.

The claims made in the current study are open to verification or refutation by others working in the field of text analysis or in other approaches towards the study of language. Views which complement or challenge the claims made in the current study in one way or another enrich systemic

semantic functional explorations into the study of language with significant theoretical and pedagogical implications.

Notes

- ¹ The lexicogrammatical stratum sees the unity of syntax and lexis, as a single unit of linguistic analysis. This is an idea posited by Halliday in 1966, in his paper "Lexis as a Linguistic Level" when he suggested that "lexical patterns" be handled "as different in kind, and not merely in delicacy"
- ² The system of the clause complex in SFL is handled under the logical function of language. A clause complex is formed when clauses are linked. There are two systems involved in the formation of clause complexes which are (i) the system of *taxis* which describe the type of interdependency relations between clauses linked into clause complexes: *parataxis* and *hypotaxis* and (ii) the system of *logico-semantic* relations which describe the specific type of meaning relation between linked clauses: *elaboration*, *extension* and *enhancement*.
- ³ Halliday says that is a scale of rank in every language which may be represented as clause, phrase/group, word and morpheme; however, there may be variation in terms of the work carried out by the unit of rank. In English, clauses are structurally linked through a series of clause complexes. A ranking clause is a clause that functions in the structure of its own rank as opposed to a rankshifted or downranked clause.
- ⁴ A rankshifted or embedded clause is a clause that functions in the structure of a rank next below it. For example a clause may function as a group or a group may function as a word.
- ⁵ A technical name to show sequence of clauses linked in parataxis (clauses of equal status linked) and hypotaxis (clauses of unequal status linked). For paratactic clauses, the first clause is always the initiating clause and the second clause the continuing clause. However, in a *hypotactic* structure, the elements are ordered in dependence. The positioning of the dominant clause, *alpha* (a) and dependent clause, *beta* (b) are fundamentally independent of sequence.
- ⁶ The system of *taxis* or interdependency between clauses may be of two kinds: parataxis or hypotaxis.
- ⁷ Logico semantic relations refer to the kind of semantic relation made between clauses that are linked: elaboration, extension or expansion.
- ⁸ In SFL, the clause complex is treated as a *univariately* structured complex rather than as a *multivariately* structured unit. Only *logico-semantic* meanings are expressed as part/part structures also known as *univariate* structures. *Experiential*, *interpersonal* and *textual* meanings are expressed as part/whole or *multivariate* structures.

- ⁹ The finite is the element in clause that has the function of making the proposition finite either by reference to time or judgement of the speaker. The predicator is realised by a verbal group without a reference to time or judgement.
- ¹⁰ Logical connectors are either linkers (and, but, or etc.) or binders (which, since, if etc.) which are used to connect one or more clauses together to form a clause complex.
- ¹¹ An instance of cohesion in text is achieved through ellipsis when we leave out something which can be recoverable from the preceding text. Ellipsis works with certain grammatical structures; for example, in English the subject in the second clause is usually left out when clauses are co-ordinated by “and” as in *My mother went to town and bought me some blue ribbons.*

References

- Biber, D., Conrad, S. & Repper, Randi. (1998). *Corpus linguistics. investigating language structure and use*. UK. Cambridge University Press.
- Christian G. (2004). *Analytical Chemistry*. U.S.. John Wiley & Sons.
- Creswell, John W. (1994). *Research design quantitative and qualitative approaches*. U.S. Sage.
- Eggins, S. (2004). *Introduction to Systemic Functional Linguistics*. NY: Continuum International Publishing Sop Ltd.
- Halliday, M.A.K. (1961). Categories of the theory of grammar. *WORD*, 17, 242-292.
- Halliday, M.A.K. & Martin, J.R. (1993). *Writing science. literacy and discursive power*. London. The Falmer Press.
- Halliday, M.A.K. (1996). On grammar and grammatics. In C. Cloran, D. Butt & R. Hasan (Eds.) *Functional descriptions theory into practice*. (p. 1-38). Amsterdam. John Benjamins.
- Halliday, M.A.K. & Matthiessen, Christian. (2004). *An introduction to functional grammar*. London. Arnold.
- Kress, G. & van Leeuwen, T. (2001) *Multimodal discourse – the modes and media of contemporary communication*. London. Arnold
- Lemke, J. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J.R. Martin & Robert Veel (Eds.). *Reading science. Critical and functional perspectives on discourses of science*. London. Routledge
- Martin J.R. (1989). *Factual writing exploring and challenging social reality*. Oxford: Oxford University Press (first published in 1985 by Deakin University Press)
- Martin, J.R. (1995). Text and clause: Fractal resonance. *TEXT*, 15, (1), 5-42.
- O'Halloran, Kay L. (2000). Classroom discourse in Mathematics: A multisemiotic analysis. *Linguistics and Education*, 10, (3), 359-388.

- O'Halloran, Kay L. (2003). Educational implications of Mathematics as a multisemiotic discourse. In M. Anderson, A. Sáenz-Ludlow, S. Zellweger & V. V. Cifarelli. (Eds.) *Educational perspectives on Mathematics as semiosis From thinking to interpreting to knowing*. (p.185-214). NY. Legas.
- Patton, Michael Quinn. (1990). *Qualitative evaluation and research method*. US. Sage.
- Pavia, Donald L., Lampman, Gary M., Kriz, George S. & Engel, Randall G. (1999). *Introduction to organic laboratory techniques. A microscale approach*. U.S. Saunders College Publishing.
- Rouessac, Francis & Rouessac, Annick. (2000). *Chemical analysis. Modern instrumentation methods and techniques*. England: John Wiley & Sons
- Rubinson & Rubinson. (1998). *Contemporary chemical analysis*. New Jersey: Prentice Hall
- Sinclair, John McH. (1992). Trust the text: The implications are daunting. In Martin Davies & Louise Ravelli. (Eds.). *Advances in systemic linguistics. recent theory and practice*. (p. 5 – 19). London & New York: Pinter Publishers.
- Skoog D.A. et al. (2000). *Analytical chemistry: an introduction*. US: Saunders College Publishing
- Srniwass, Sridevi. (2006a). Knowledge Construction in the Genre of Chemistry Textbooks: A Systemic Functional Perspective. Unpublished Doctoral Thesis. University of Malaya.
- Srniwass, Sridevi. (2006b) Systemic perspectives on the clause complex in English: Logico-semantic relations in chemistry. In Zuraidah Mohd. Don (Ed.). *English in a globalised environment. the present day reality in Malaysia*. Kuala Lumpur: University of Malaya Press. pp. 55-85
- Srniwass, Sridevi. (2008). *Tactic Augmentation and Circumstantial Augmentation in the Creation of Field Meanings*. In Carys Jones and Eija Ventola (eds.) in *From Language to Multimodality New Developments in the Study of Ideational Meaning: EQUINOX Publishing Ltd. U.K. (Series Functional Linguistics edited by Professor Robin Fawcett.)*