AXEL: A FRAMEWORK TO DEAL WITH AMBIGUITY IN THREE-NOUN COMPOUNDS

A Thesis submitted for the degree of Doctor of Philosophy

by Jorge Matadamas Martinez

School of Information Systems, Computing and Mathematics
Brunel University of West London

September 30, 2010

Abstract

Cognitive Linguistics has been widely used to deal with the ambiguity generated by words in combination. Although this domain offers many solutions to address this challenge, not all of them can be implemented in a computational environment. The Dynamic Construal of Meaning framework is argued to have this ability because it describes an intrinsic degree of association of meanings, which in turn, can be translated into computational programs. A limitation towards a computational approach, however, has been the lack of syntactic parameters. This research argues that this limitation could be overcome with the aid of the Generative Lexicon Theory (GLT). Specifically, this dissertation formulated possible means to marry the GLT and Cognitive Linguistics in a novel rapprochement between the two.

This bond between opposing theories provided the means to design a computational template (the AXEL System) by realising syntax and semantics at software levels. An instance of the AXEL system was created using a Design Research approach. Planned iterations were involved in the development to improve artefact performance. Such iterations boosted performance-improving, which accounted for the degree of association of meanings in three-noun compounds.

This dissertation delivered three major contributions on the brink of a so-called turning point in Computational Linguistics (CL). First, the AXEL system was used to disclose hidden lexical patterns on ambiguity. These patterns are difficult, if not impossible, to be identified without automatic techniques. This research claimed that these patterns can assist audiences of linguists to review lexical knowledge on a software-based viewpoint.

Following linguistic awareness, the second result advocated for the adoption of improved resources by decreasing electronic space of Sense Enumerative Lexicons (SELs). The AXEL system deployed the generation of "at the moment of use" interpretations, optimising the way the space is needed for lexical storage.

Finally, this research introduced a subsystem of metrics to characterise an ambiguous degree of association of three-noun compounds enabling ranking methods. Weighing methods delivered mechanisms of classification of meanings towards Word Sense Disambiguation (WSD). Overall these results attempted to tackle difficulties in understanding studies of Lexical Semantics via software tools.

Acknowledgments

Any token of gratitude is always a culturally charged symbol that defines any person from the Latino world, like me. We, Mexicans, give thanks to everything. More than one person was involved in this gigantic task –it looked gigantic to me- of submitting this doctoral dissertation. Particularly my research received a potent drive however, from those who were left in my life, literally less than a handful of people, very often visiting me in my dreams only. I want to thank them all because without them, this work would not have been possible.

Naturally it is not right to single out anyone, because this project is teamwork by countless people, however my special thanks go to Axel and Eric –my children-, Dr. Alan Serrano –my first supervisor-, Dr. George Ghinea –my second supervisor- and Mrs. Yvonne Harvey –my incredibly friendly proofreader.

I became joyful waiting for this day to come which is why I would like to give thanks to our Lady of Guadalupe and Tata Dios. Our Lady of Guadalupe is not a symbol but our Mother, caring Mother. Tata Dios is the Master of the Universe and a loving Father. I want to thank them both from my heart as if this is praising gratitude.

Last but not least, my substantial debt to all my colleagues and people at St Johns for their support, on the whole, always positive. However I was living in the dark after funding cuts from the Mexican Agency –CONACYT- struck, their smiles and helpful comments were instrumental towards finishing this project. I have really much appreciated that,

Thank you very much to all of you.

Declaration

The following paper has been submitted as a direct result from this dissertation, as of writing awaiting submission results:

Conference Paper:

Matadamas, J., Serrano, A., Ghinea, G. (2010). **"AXEL: Cognitive Approach towards Automatic Classification of Ambiguous Noun Compounds via Preposition-based Paraphrasing"**. CBA 2010, Corpus-Based Approaches to Paraphrasing and Nominalization, December 1-2, 2010. Barcelona. Spain.

Index

1. BACKGROUND 1

1.1. LEXICAL AMBIGUITY 1

1.1.1. Computational Sense Generation and Ambiguity 1

1.1.2. Lexical Ambiguity, Cognitive Linguistics and Compounding 3

1.1.3. A Cognitive Framework Dealing with Ambiguity 3

1.2. DEALING WITH AUTOMATIC AMBIGUITY 6

1.2.1. Significance of Noun Compound Ambiguity 6

1.2.2. Towards Automatic Lexical Sense Generation 7

1.3. DISSERTATION ORGANISATION 9

1.3.1. Research Aim 9

1.3.2. Research Objectives 9

1.3.3. Expected Benefits 11

1.3.4. Thesis layout 12

1.3.5. Chapter Summary 16

2. DESIGN RESEARCH METHODOLOGY 17

2.1. DESIGN SCIENCE PROCESSES 17

2.1.1. Arguing the Strengths of Design Research 17

2.1.2. Design Research Processes for this Dissertation 18

2.1.3. Iterations in the Present Design Research Process 23

3. LITERATURE REVIEW 25

3.1. AWARENESS ON NOUN COMPOUNDING 25

3.1.1. Introduction 25

3.1.2. Compositional Nature of Noun Compounds 25

3.1.3. Recursive Approach to Higher-arity Compounding 27

3.1.4. Computational Criteria for Paraphrasing 30

3.1.5. Syntax-driven Elements 36

3.1.6. Chapter Summary 40

4. ARTEFACT-INTENSIVE PROCESSING 43

4.1. CONSTRUCTS, MODELS AND PROPOSAL 43

4.1.1. Introduction 43

4.1.2. Constructs 43

4.1.3. Models 46

4.1.4. The Proposal 50

4.2. THE TENTATIVE DESIGN 56

4.2.1. Initial Settings 56

4.2.2. Methods of the Design D 57

4.2.3. The Tentative Design D 61

4.2.4. Chapter Summary 64

5. IMPLEMENTATION 65

5.1. THE DEVELOPMENT STAGE 65

5.1.1. Introduction 65

5.1.2. WordNet as a Knowledge Base 66

5.1.3. Functional Requirements 69

5.1.4. Use-Case Model for the Artefact A 70

5.2. SEMANTICALLY HAND-CODED SETS 73
5.2.1. Preposition Semantics for NC Interpretation 73
5.2.2. Heuristics 79
5.2.3. Prepositional Paraphrasing Mappings: Summary 85
5.2.4. Implementation of Artefact A 87
5.2.5. Chapter Summary 89

6. EVALUATION 91
6.1. TEST SET PREPARATION 91
6.1.1. Introduction 91
6.1.2. The software 92
6.1.3. The WordNet Searching Interface 92
6.1.4. The Supervised Model 94
6.1.5. The Two-noun Compound Set 95
6.1.6. The Three-noun Compound Set 97
6.2. ARTEFACT ASSESSMENT 100
6.2.1. Experiment on NNC Interpretation 100
6.2.2. Two-noun Compound Results of the First Iteration 102
6.2.3. Iterations for the Two-noun Compound Experiment 103
6.2.4. Two-noun Compound Results of the Second Iteration 108
6.2.5. Experiments on the Three-noun Compound Sets 109
6.2.6. Three-noun Compound Results 110
6.3. RESULTS COMPARISON 111
6.3.1. Previous Comparison on the Two-noun Compound Set 111
6.3.2. Previous Comparison on the Three-noun Compound Set 112
6.3.3. Lexical Results on the Three-noun Compound Set 113
6.3.4. Chapter Summary 115

7. CONCLUSIONS 119
7.1. MAIN CONTRIBUTIONS 119
7.1.1. The Three Main Contributions 119
7.1.2. Informing Linguists' Theories via Software Tools 120
7.1.3. Tackling Limitations of Sense Enumerative Lexicons 120
7.1.4. Classifying Degrees of Association 121
7.2. CONTRIBUTIONS TOWARDS ARTEFACTS 122
7.2.1. The Result Artefact: Summary 122
7.2.2. Future Considerations 123

8. REFERENCES 127
8.1. BOOKS, JOURNALS, CONFERENCES, AND WEBSITES 127
8.1.1. Referenced Literature 127

9. APPENDIXES 133
9.1. SUPPORTING MATERIAL 133
9.1.1. Appendix A: Two-noun Compound Results 133
9.1.2. Appendix B: Three-noun Compound Results 139
9.1.3. Appendix C: Variable Coding of the AXEL System 143
9.1.4. Appendix D: Heuristics for Lexical Hierarchies 153

Table of Figures

i. Table showing examples of ambiguity as defined in the literature for contrastive polysemy 2
ii. Table showing examples of ambiguity as defined in the literature for complementary polysemy 2
iii. Figure representing a process of dynamic construal of meaning for words in composition from a Cognitive Linguistics point of view (Croft, 2004). 4
iv. Table containing examples of distinct autonomous sense units or boundaries for the word "bank", taken from (Croft, 2004, p. 110). 4
v. Table containing examples of elements with compositional autonomy for the word "bank", taken from (Croft, 2004, p. 114). 5
vi. Figure showing the DR process methodology for the present research. 23
vii. Figure for describing two analysis models to characterise branching theory, taken from (Lauer, 1995b) 29
viii. Figures representing first Levi's set of Recoverably Deletable Predicates -left- which evolved into a 12-predicate table -right- to limit potential ambiguity of NCs, taken from (Downing, 1977; Nakov, 2008a) 33
ix. Figures depicting a conventional representation of inheritance relations, taken from (Pustejovsky, 1993b) 37
x. Chart representing findings of Literature Review 40
xi. Formula based on xxiii formula, representing a Construct on bracketing for left-branching approach 44
xii. Table containing Constructs to meet 1st research objective of the diagram vi defining conceptualisation in NC domains to deliver a 1st artefact. 45
xiii. Figure representing the first artefact containing primitive Constructs. 46
xiv. Table containing Models according to the diagram vi defining interrelations between Constructs to deliver the 2nd Artefact. 47
xv. Figure representing the Constraint Model (C-M01). 48
xvi. Figure representing the Syntactic Parametric Model (C-M02). 48
xvii. Figure representing the Recursive Compositionality Model (C-M03). 49
xviii. Figure representing the Prepositional Semantics Model (PS-M04). 49
xix. Figure representing the Degree of Association Model (DOA-M06). 50
xx. Chart and template representing Scenario I with values (+,-)of degree of association for FSB, to characterise AXEL NCs 54
xxi. Chart and template representing Scenario II with values (+,+)of degree of association for FSB, to characterise monosemous NCs. 54
xxii. Chart and template representing Scenario III with values (-,-)of degree of association for FSB, to characterise polysemic NCs. 55
xxiii. Chart and template representing Scenario IV with values (-,+)of degree of association for FSB, to characterise extremely polysemic NCs. 55
xxiv. Figure representing Models describing an initial research situation S_0 56
xxv. Table containing Operators according to the diagram vi defining transformations of Models to deliver the 3rd Artefact or Tentative Design. 58
xxvi. Figure representing the Constraints Operator (C-O01) 59
xxvii. Figure representing the Syntax Operator (S-O02) 59
xxviii. Figure representing the Prepositional Ways of Paraphrasing Operator (PWOP-O03). 60
xxix. Figure representing the Paraphrasing Operator (P-O04) 60
xxx. Figure representing the Association Operator (A-O05) 61
xxxi. Figure describing the Design D as a set of steps resulting in one solution of the solution space. 63
xxxii. Figure of a diagrammatic representation of lexical hierarchies in WordNet, taken from (Fellbaum, 1998) 67
xxxiii. Figure showing a screen from WordNet 2.1 containing lexical hierarchies associated to sense 6 of the noun=book. 68
xxxiv. Table representing separate lexical hierarchies considered to be simple types from the GLT, derived from sense 6 of the noun=book as queried from WordNet 2.1 68
xxxv. Figure representing separate lexical hierarchies considered to be simple types from the GLT, derived from sense 6 of the noun=book as queried from WordNet 2.1 68
xxxvi. Formula representing type transformation T for sense 6 of the noun=book as queried from WordNet 2.1 69
xxxvii. Figure representing the Use-Case diagram for modelling internal organisation of a computing implementation for the present artefact A 72
xxxviii. Figure representing Lauer's preposition set, taken from (Girju, 2009a) 74
xxxix. Figure representing Girju's mapping between 22 semantic classification categories and the Lauer's set across the Europarl corpus, taken from (Girju, 2009a, p. 202) 75
xl. Figure representing Girju's mapping between 22 semantic classification categories and the Lauer's set across the CLUVI corpus, taken from (Girju, 2009a, p. 203) 76
xli. Figure representing Girju's 22-SR set, from (Girju, 2009, p. 193) 77
xlii. Formula representing a multiple meaning approach between prepositions in a cluster associated to the SR Agent. 77
xliii. Chart representing Girju's mappings with wildcard preposition scheme 78
xliv. Table representing preposition mapping between Girju's SRs and Lauer's Prepositions 79
xlv. Formula based on formula xi , representing a left-branching Construct approach using conventional Girju's terminology. 80

xlvi. Table containing lexical hierarchy heuristics for Girju's SR POSSESSION for Arg_1 83
xlvii. Table containing lexical hierarchy heuristics for Girju's SR POSSESSION for Arg_2 83
xlviii. Table representing prepositional paraphrasing fulfilling the semantics of the AXEL System. 87
xlix. Chart showing WordNet menus for retrieving lexical hierarchies associated to search for noun "right" 93
l. Chart showing Excel spreadsheet input for the noun "right" as transferred from the WordNet GUI 93
li. Chart showing main processing flow in the artefact development, divided into two stages: 1)manual WordNet output and 2)automatic PWOP AXEL calculations 94
lii. Table showing deleted ambiguous preposition encoding for NCs in the test set....96
liii. Table showing changes to preposition encoding to be used in the test set 97
liv. Table showing Performance Measures Artefact for the AXEL System regarding formulation of criteria to evaluate artefact success....101
lv. Chart showing the performance by the supervised AXEL model on the Lauer's test set....102
lvi. Table showing new semantically sense-annotated PWOP for F paraphrasing (FROM) towards artefact improvement....103
lvii. Table showing new semantically annotated PWOP for R paraphrasing (FOR) towards artefact improvement 104
lviii. Table showing new semantically annotated PWOP for O paraphrasing (OF) towards artefact improvement .105
lix. Table showing new semantically annotated PWOP for W paraphrasing (WITH) towards artefact improvement 106
lx. Table showing new semantically annotated PWOP for T paraphrasing (ABOUT) towards artefact improvement 106
lxi. Chart representing Use-Case diagram for modelling a second AXEL System version, showing internal system organisation with changes in the computational heuristics.....107
lxii. Chart showing the performance by the supervised AXEL model on the Lauer's test set in the second iteration 108
lxiii. Chart showing left-branching bracketing performance by the supervised AXEL model on the Lauer's NNNC test set....110
lxiv. Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNC test set for the first iteration 111
lxv. Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNC test set for the second iteration....112
lxvi. Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNNC test set for bracketing accuracy 113
lxvii. Chart showing distribution of ambiguous content according to integration (IOF) and ontological distinctness (ODOF)measures for the NNNC Lauer's corpus 114
lxviii. Table showing measurable results throughout the Design Process as part of the Results Artefact....123
lxix. Table showing NNCs used in the test experiment....138
lxx. Table showing NNNCs used in the test experiment 141
lxxi. Code showing instructions for variable definition of the AXEL System 1.1 146
lxxii. Code showing instructions for variable definition of the AXEL System 1.2 152
lxxiii. Table containing lexical hierarchy heuristics for Girju's SR KINSHIP for Arg_1 153
lxxiv. Table containing lexical hierarchy heuristics for Girju's SR KINSHIP for Arg_2 154
lxxv. Table containing lexical hierarchy heuristics for Girju's SR PROPERTY for Arg_1 155
lxxvi. Table containing lexical hierarchy heuristics for Girju's SR PROPERTY for Arg_2 155
lxxvii. Table containing lexical hierarchy heuristics for Girju's SR AGENT for Arg_1 156
lxxviii. Table containing lexical hierarchy heuristics for Girju's SR AGENT for Arg_2....156
lxxix. Table containing lexical hierarchy heuristics for Girju's SR TEMPORAL for Arg_1....157
lxxx. Table containing lexical hierarchy heuristics for Girju's SR TEMPORAL for Arg_2....157
lxxxi. Table containing lexical hierarchy heuristics for Girju's SR DEPICTION for Arg_1 158
lxxxii. Table containing lexical hierarchy heuristics for Girju's SR DEPICTION for Arg_2 158
lxxxiii. Table containing lexical hierarchy heuristics for Girju's SR PART-WHOLE for Arg_1....159
lxxxiv. Table containing lexical hierarchy heuristics for Girju's SR PART-WHOLE for Arg_2....160
lxxxv. Table containing lexical hierarchy heuristics for Girju's SR IS-A-HYPERNYM for Arg_1 161
lxxxvi. Table containing lexical hierarchy heuristics for Girju's SR IS-A-HYPERNYM for Arg_2 161
lxxxvii. Table containing lexical hierarchy heuristics for Girju's SR PRODUCE for Arg_1 161
lxxxviii. Table containing lexical hierarchy heuristics for Girju's SR PRODUCE for Arg_2 162
lxxxix. Table containing lexical hierarchy heuristics for Girju's SR INSTRUMENT for Arg_1....162
xc. Table containing lexical hierarchy heuristics for Girju's SR INSTRUMENT for Arg_2 163
xci. Table containing lexical hierarchy heuristics for Girju's SR LOCATION for Arg_1 163
xcii. Table containing lexical hierarchy heuristics for Girju's SR LOCATION for Arg_2 164
xciii. Table containing lexical hierarchy heuristics for Girju's SR PURPOSE for Arg_1 165
xciv. Table containing lexical hierarchy heuristics for Girju's SR PURPOSE for Arg_2 165
xcv. Table containing lexical hierarchy heuristics for Girju's SR SOURCE for Arg_1....166
xcvi. Table containing lexical hierarchy heuristics for Girju's SR SOURCE for Arg_2....166
xcvii. Table containing lexical hierarchy heuristics for Girju's SR TOPIC for Arg_1....167
xcviii. Table containing lexical hierarchy heuristics for Girju's SR TOPIC for Arg_2....167
xcix. Table containing lexical hierarchy heuristics for Girju's SR MANNER for Arg_1 168
c. Table containing lexical hierarchy heuristics for Girju's SR MANNER for Arg_2 168
ci. Table containing lexical hierarchy heuristics for Girju's SR EXPERIENCER for Arg_1 169
cii. Table containing lexical hierarchy heuristics for Girju's SR EXPERIENCER for Arg_2 169

ciii. Table containing lexical hierarchy heuristics for Girju's SR MEASURE for Arg_1 170
civ. Table containing lexical hierarchy heuristics for Girju's SR MEASURE for Arg_2 170
cv. Table containing lexical hierarchy heuristics for Girju's SR THEME for Arg_1 172
cvi. Table containing lexical hierarchy heuristics for Girju's SR THEME for Arg_2 172
cvii. Table containing lexical hierarchy heuristics for Girju's SR BENEFICIARY for Arg_1 173
cviii. Table containing lexical hierarchy heuristics for Girju's SR BENEFICIARY for Arg_2 173

Table of Acronyms

Acronym	Acronym Stands for
CL	Computational Linguistics
MT	Machine Translation
IE	Information Extraction
IR	Information Retrieval
QA	Question-answering
WSD	Word Sense Disambiguation
NP	Noun Phrase
CN	Complex Nominal
TCN	Technical Complex Nominal
NC	Noun Compound
NNC	Noun-Noun Compound or Two-noun Compound
NNNC	Noun-Noun-Noun Compound or Three-noun Compound
GLT	Generative Lexicon Theory
FSB	Full Sense Boundary or Full Sense
IOF	Integration of Facets
ODOF	Ontological Distinctness of Facets
SEL	Sense Enumeration Lexicon
Artefact	Artefact as part of the DR terminology
Construct	Constructs as part of the DR terminology
Model	Models as part of the DR terminology
Method	Methods as part of the DR terminology
Proposal	Proposal as part of the DR terminology
AI	Artificial Intelligence
Operator	Operator as part of the AI Paradigm terminology
AXEL	Autonomously Exclusive Element of the Lexicon
DR	Design Research
RDP	Recoverably Deletable Predicate
SR	Semantic Relation
PWOP	Prepositional Ways of Paraphrasing

To my children, whom I will always remember who are capable of lively excitement enjoying the simple things of life no matter the whereabouts, teaching me any place can be the place one belongs to…

"[Esteban] se maravillaba al observar como el lenguaje había tenido que usar de la aglutinación, la amalgama verbal y la metáfora para traducir la ambigüedad formal de cosas que participaban de varias esencias. Del mismo modo que ciertos árboles eran llamados **acacia pulsera**, **ananás porcelana**, **madera costilla, primo trébol,** […], **piñón botija**, **tisana nube, palo iguana** […], muchas criaturas marinas recibían nombres que por fijar una imagen establecían equívocos verbales originando una fantástica zoología de **peces perro, peces buey, peces tigre**, […] sin olvidar al **pez vieja, el pez capitán** […], y el **pez mujer** -el misterioso y huidizo manatí, entrevisto en bocas de río, donde lo salado y lo de manantial se amaridaban- con su estampa femenina y sus pechos de sirena"

Alejo Carpentier
El siglo de las luces

"[Esteban] marvelled to realise how the language of these islands has made use of agglutination, verbal amalgams, and metaphors to convey the formal ambiguity of things which participated in several essences at once. Just as certain trees were called **acacia bracelet**, **pineapple porcelain**, **wood rib**, **cousin clover**, […] **pitcher pine kernel**, **cloud tisane**, **iguana stick**, many marine creatures had received names, which established verbal equivocations […], thus a fantastic bestiary had arisen of **dog fish, ox fish, tiger fish**, […] not forgetting the **vieja fish**, the **captain fish**, […] and the **woman fish** –the mysterious and elusive manatees, glimpsed in the mouths of rivers where the salt water mingled with the fresh- with their feminine profiles and their siren's breasts".

Alejo Carpentier
Explosion in a cathedral

1. BACKGROUND

1.1. LEXICAL AMBIGUITY

1.1.1. Computational Sense Generation and Ambiguity

Most of the time speakers of a language are not aware of the several potential senses of an ambiguous word, therefore seldom representing a problem at all for humans. Notwithstanding, ambiguous words are spanning the human speech very often indeed. For example, it has been calculated that the 121 most used nouns in English have 7.8 meanings each, on average (Agirre, 2006). On the other hand, substantial difficulty to handle ambiguity is experienced by computers that fall short of performing at the same level as humans (Fellbaum, 1998).

Ambiguity poses for the problem to deal with the right meaning for an expression between several possible meanings. The origins of the problem dates back to the late 1940's and early 1950's when Machine Translation (henceforth MT) had grinded to a halt (Wilks, 2006; Agirre, 2006, Malmkjaer, 1991). MT Tasks were significantly hampered due to the numerous senses some words had (Malmkjaer, 1991; Navigli, 2009).

Ambiguity reflects a great diversity of ambiguous formations experienced at different levels, namely single words and collection of words. When dealing with multiple meanings of a word, language involves polysemy on elements in isolation from text (Agirre, 2006). Whereas, when collections of words are involved, language deals with ambiguity. Complementary polysemy or simple polysemy is meant to be a lexical condition when a word realises two or more related, though separate meanings (Cowie, 2006). On the other hand, homonymy or contrastive polysemy is a lexical condition when a word has one or more unrelated senses, realising more than one lexical item (Pustejovsky, 1998; Agirre, 2006; Weinreich, 1964 in Pustejovsky, 1995; Stokoe, 2005).

Noun	Sense	Type	Related Terms?
Bank	financial institution	contrastive polysemy	☒
Bank	slope of a river	contrastive polysemy	☒

i. Table showing examples of ambiguity as defined in the literature for contrastive polysemy

Noun	Sense	Type	Related Terms?
Bank	financial institution	complementary polysemy	☑
Bank	staff	complementary polysemy	☑
Bank	building	complementary polysemy	☑

ii. Table showing examples of ambiguity as defined in the literature for complementary polysemy

Ambiguity, either as contrastive or complementary polysemy, motivates theoretical Word Sense Disambiguation (henceforth WSD) work to solve the problem of selecting the right meaning of an expression. The standard approach to disambiguating has included listings of all collected word senses to select one that could fit a particular situation. This way ambiguity has been tackled. However, some meanings might not be covered in the list of enumerative senses excluding relevant meanings for certain domains (Pustejovsky, 1995).

Sense generation as opposed to sense storage, unlocks computational capacities generating all meaningful senses to reduce semantically ill-formed ones. This way ambiguity can be narrowed down. This idea is not new. Some theoretical models have proposed using computational tools to detail interpretation for acquiring lexical information from language structures (Pustejovsky, 1995; Lynott; 2004). As a result, automatic sense generation constrains the number of meaningless senses reducing ambiguity, while outlining a ranking system of the generated senses towards WSD (Lynott, 2004).

This way computational tools have contributed to the problem of automatic acquisition of lexical patterns of text corpora, advocating for a turning point in Computational Linguistics (henceforth CL), where software tools can inform linguistic theories about lexical ambiguity (Pustejovsky, 1995).

1.1.2. Lexical Ambiguity, Cognitive Linguistics and Compounding

Lexical Semantics is a linguistic discipline that study words and therefore deals with ambiguity. Ambiguity has caught linguists' interest by focusing on noun compounds (henceforth NC). Cognitive Linguistics evolved a word meaning theory that appeared to have alternatively pivotal influence on Lexical Semantics by tackling ambiguity of meanings of words in combination (Croft, 2004; Lynott, 2004).

Introduction of cognitive concepts has explained conceptual combination mechanisms as a major way of building lexical knowledge of words in combination (Shin, 2000, Smith & Medin, 1981 in Smith, 1984). Conceptual combination therefore parallels noun compounding, and enables productivity by combining simple concepts into complex concepts (Smith, 1984).

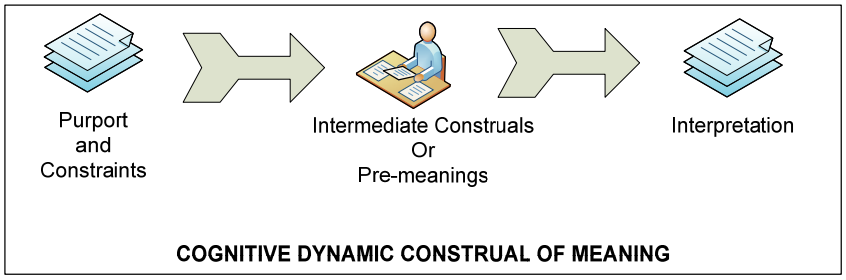
Overall, productivity in NCs or conceptual combinations is challenging and involves systematically constrained creativity of the language characterising it as learnable, systematic and truly productive (Onysko, 2009, Weiskopf, 2007, Johnston, 1995; Downing, 1977). Ambiguity and creativity in NCs have renewed interest to understand long-standing analyses in Cognitive Semantics (Smith, 1984; Costello, 1996; Wisniewski, 1998; Wilkenfeld, 2001; Costello, 2002; Gagné, 2002; Lynott, 2004a; Devereux, 2005; Costello, 2006; Maguire, 2007; Choi, 2007; Maguire, 2010).

1.1.3. A Cognitive Framework Dealing with Ambiguity

Croft (2004) has outlined a cognitive framework called "the dynamical construal of meaning" to integrate fixed structural properties of the lexicon –the hard part of the framework- and the apparently infinite flexibility –the soft part of the framework- of meaning in context.

The internal organisation of this cognitive framework rests upon structural relations and meanings being construed "on-line" or "at the moment of use". This framework aims to address sense generation for words in combination.

A construal –conceptualisation- is an operation of the language providing for an alternative meaning for what appears to be truth-functionally equivalent words in combination (Croft, 2004). Essentially, conceptualisation enables word usage to produce meaning. In order to do this, the framework processes linguistic input –purports and constraints- and generate meanings –interpretation- through construals –pre-meanings- as shown below:



iii. Figure representing a process of dynamic construal of meaning for words in composition from a Cognitive Linguistics point of view (Croft, 2004).

Sense boundary construals are central in the dynamical construal of meaning to interpret meanings of words on different occasions of use by delimiting an autonomous unit of sense (Croft, 2004). Below the following table illustrates the sense boundary construal for concept “bank”:

Words in Combination	Word	Autonomous Unit of Sense
A sperm bank	bank	collection and custody of some other commodities, but money
We moored the boat to the bank	bank	a physical slope by a riverside
A high-street bank	bank	financial institution for the collection and custody of money

iv. Table containing examples of distinct autonomous sense units or boundaries for the word “bank”, taken from (Croft, 2004, p. 110).

Sense boundary construals do not take into account polysemy/homonymy distinctions which confirms the viewpoint that differences in polysemy and homonymy are of little relevance in cognitive research (Croft, 2007; Taylor, 2002).

Autonomy is a sense boundary effect describing the ability of a unit to behave independently of other units that might be construed in the same context (Croft,

2004; Cruse, 1995). These boundary effects have a big impact on words in composition enabling a portion of the participating elements to engage with a portion of the meaning of others (Croft, 2004; Cruse, 1995; Cruse, 2001). This portion is said to have compositional autonomy and is called a Full Sense Boundary (henceforth FSB). The following table illustrates this:

Words in Combination	Autonomous Word	Engaging Element	Portion of Meaning Engaged	Portion of Meaning Left Out
A steep bank	bank	steep	a physical slope by a riverside	financial institution for the collection and custody of money
A high-street bank	bank	high-street	financial institution for the collection and custody of money	a physical slope by a riverside

v. Table containing examples of elements with compositional autonomy for the word "bank", taken from (Croft, 2004, p. 114).

This cognitive framework enables the association of meanings to handle ambiguity of words in combination. Resulting FSBs will be integrated by means of a degree of association, which is explained by an index of integration (henceforth IOF) and an index of ontologically distinctness (henceforth ODOF) of the words in composition. Croft's framework (2004) states that the lower the degree of integration, the more likely the FSB will behave as a polysemic sense. On the other hand, a reduction of ontological distinctness will lead to a loss of autonomy in FSBs, resulting in monosemous senses.

Ultimately, the dynamic construal of meaning will be able to handle ambiguity of words in composition advocating for "on-line" meanings. Ambiguity is explained by association of meanings through the interplay of integration and ontological distinctness measures. Measures of association represent either polysemic or monosemous metrics for characterising lexical ambiguity for words in composition.

1.2. DEALING WITH AUTOMATIC AMBIGUITY

1.2.1. Significance of Noun Compound Ambiguity

Essentially this section will attempt to emphasise the fact that lexical ambiguity in noun compounding is of paramount importance for dealing with automatic sense generation and its consequences.

NC long-standing relevance is far from waning and computational linguists and linguists alike are still researching into NC ambiguity with enthusiasm (Johnston, 1996; Wilkenfeld, 2001; Lapata, 2000; Costello, 2002; Gagné, 2002; Moldovan, 2004b; Lynott, 2004; Nakov 2006; Kim, 2007; Girju, 2009a).

Ambiguity in NLP applications appears to be a fundamental outcry since WSD tools should be dealing with casting a more rewarding experience to solve the "Do what I mean, not what I say" information search problem (Shepherd, 2007). Intuitively, NC constructions account for the vast majority of users' queries in IR as they tend to naturally express requests in terms of conjunction of nouns (Pustejovsky, 1995a). Evidently, users are not fully satisfied with the performance of IR when it comes to finding information due to the poor quality of ambiguous resources, which stops users from a rewarding experience (Kobayashi, 2000).

NC queries drive critical ways of requesting information in technical domains due to ambiguity. Technical Complex Nominals (henceforth TCNs) are not reflected in Sense Enumerative Lexicons (henceforth SEL) –dictionaries- due to the fact the technical elements are not generated (Arens 1987; Johnston, 1995). Noun conjunction proliferation has become a hard challenge due to the impending emergency of ambiguous new terms in various sources, like biomedical text corpora, engineering documentation, and technical maintenance manuals (Isabelle, 1984; Arens, 1987; Barker, 1998a; Rosario, 2001)

NCs are a crowded class across several text corpora. For instance, in the British National Corpus, NCs account for roughly 2.6% of its composition, while in the

Reuters Corpus, NCs are as much as 3.9% out of all tokens (Baldwin, 2004). Similarly, in the Brown Corpus, noun compounding is approximately 8% of the total corpus (Francis, 1982 in Sproat, 1987). In the Europarl corpus, Girju (2009a) sampled 10,000 sentences, out of which were extracted 6,200 token instances of CNs. From these, Girju (2009a) detected that around 49.62% were deployed as Noun-Noun Compound (henceforth NNC) constructions.

The Generative Lexicon Theory (henceforth GLT) studies the meaning of noun categories to outline an integrated view of the English lexicon accounting for a broader coverage (Pustejovsky, 1995; Pustejovsky, 1993a). To this end, offshoots of the GLT have computationally enriched NC approaches and have advocated to evolve SELs into intelligent sources concerning computational ambiguity (McDonald, 1994; Johnston, 1996). Overall, computational tractability is expected to improve the automatic treatment of the lexicon because it can ultimately enrich lexical structures with nominal acquisition (Pustejovsky, 1993a; Johnston, 1995; Johnston, 1996).

1.2.2. Towards Automatic Lexical Sense Generation

Theoretically the design of the “dynamic construal of meaning” framework deals with flexible interpretation of meanings for words in combination “on-line”. The framework, however, does not outline an approach to computational implementation of “on-line” parts of the model. Nor does it focus specifically on the generation of NC meanings to account for the explanation of compounding ambiguity.

Although the framework integrates stored stock-in-trade –lexical relations of words- and dynamic mechanisms of meaning construction –sense boundary construals- towards handling of lexical interpretation, it does not drive automatic linguistic acquisition for confirming/disconfirming theories of NC ambiguity. Nor does this framework outline the guidelines for ranking all generated lexical interpretations to deal with meaningful classification of ambiguous NCs.

Ultimately, it has been acknowledged the ranking and weighting methods complement the selection approach at a later stage towards WSD (Lynott, 2004). The framework's "on-line" layout does not advance computational ranking of interpretations in NCs, though it advocates for machine-learning techniques to deal with generated senses.

The discriminating criteria have been useful in dealing with complex multiple senses for a number of major NLP tasks, namely Machine Translation (henceforth MT), Question-answering (henceforth QA), Information Extraction (henceforth IE), document summarisation, IR, etc. (Wilks, 2006). The dynamic construal of meaning does not foresee automatic acquisition of NC ambiguity, resulting in linguists not being involved in critical revision or the reformulation of NC hidden complexities.

Complexity grows in line with superior compounding beyond four noun constituents. Hence, manageable NC structures in the lexicon have capped ambiguity complexity studies as the Literature indicates that disambiguating large number of words does not really benefit NLP tasks (Navigli, 2009). However smaller compounding structures are a better experimental drive to disclose lexical patterns, two-noun compound (henceforth NNC) studies have not covered the global views of the English lexicon. Three-noun compound (henceforth NNNC) studies provide therefore a broader coverage of text corpora to produce a more robust awareness of the lexicon (Pustejovsky, 1995)

Overall, the dynamic construal of meaning does not express a tractable opportunity grounded on automatic NNNC awareness, stopping recursive compounding from contributing to the understanding of linguistic theories on ambiguity (Pustejovsky, 1995).

1.3. DISSERTATION ORGANISATION

1.3.1. Research Aim

Revision from the last section has sketched a possible solution regarding the drawbacks of the dynamic construal of meaning framework, which is provided as a general aim for this research, as follows:

> ⌦ **Research Aim**: This research aims to develop a computational template that generates "at the moment of use" interpretations, which deals with ambiguity of three-noun compounds.

The template will be instantiated as a software tool to extend the dynamic construal of meaning framework with computationally generated "on-line" interpretations of three-noun compounds. Ultimately, this research will develop a ranking system for prioritising generated senses of a NNNC.

Underlying paraphrasing for interpretation will enable ambiguity ranking according to integration (IOF Index) and ontological distinctness (ODOF Index) measures. In dealing with ambiguous semantic interpretations, the aim of this research attempts to explain the approach to generative noun compounding meanings.

The next section will focus on the analysis of this research, which will aim to break it down.

1.3.2. Research Objectives

> ⌦ **1st Objective- Identifying Constructs:** This objective will fulfil identification of vocabulary –Constructs (henceforth terminology for Construct with first letter in capitals)- to clarify findings. Construct identification will inform the task of isolating both structure and nature of the unknown operations

in the computational template. Constructs will therefore symbolise primitive vocabulary from the noun compounding domain in the Literature. Identified elements will provide characterisation of the interplay in the problem domain for further use in the formulation of operations of the unknown computational template. The preceding background will be used to outline directions of Construct definitions, referring to bracketing, NC modelling, compounding constraints, etc. Such task will result in practical deliverable –table- containing the Construct acquisition.

⌦ **2nd Objective- Template Proposal:** This objective will develop a Proposal (henceforth terminology for Proposal with first letter in capitals) of the connections among Constructs from the 1st Objective in order to specify how unknown interrelations will operate. Models (henceforth terminology for Model with first letter in capitals) of the computational template will translate unspecified functionality, behaviours and logical interaction into a solution. Basically, the element interplay will specify interaction of the Design parts that will capture the reality of the unknown computational template, for instance: recursive compounding, retrieval of lexical hierarchies, and processing of integration/ontological distinctness to formulate ranking. These interaction statements will rule the immediate Construct realisation, which will provide for problem representation. Finally a Proposal will be delivered.

⌦ **3rd Objective- Template as a Tentative Design:** This objective will realise Methods (henceforth terminology for Method with first letter in capitals) –a procedural set of steps-

towards the template's computational tractability, involving transformation of Constructs and Models from 2nd Objective. Unknown Methods will of course specify a plain representation of solutions in the NC domain. Internally such Methods will embody bundles of data, vocabulary, algorithms and heuristics from the 1st Objective and the 2nd Objective, resulting in a template Design D. These Methods will assemble internal indexes of association towards a fully operational computational template. The Tentative Design will be delivered.

The above objectives have described a procedural set of actions in order to fulfil the general aim of this research. The above three objectives will provide operating levels of research. Basically, details of the research deliverables and the main organisation of the solution will be outlined, analysed, managed, processed and fulfilled in Chapter 2.

1.3.3. Expected Benefits

The present extended framework easily lends itself to enable a connection between empirically theoretical Linguistics and logically formalised Linguistics, a state of affairs on enormous stakes. Without such connection, it will be difficult and unproductive to carry out computational research as it has turned out that without generating "at the moment of use" meanings, linguistic contributions are missing out (Pustejovsky, 1995). Linguists can be informed by computational lexicographic resources. Conversely, computational tools can potentially profit from disclosed awareness of the structure of lexical items (Pustejovsky, 1995).

A computational approach to automatic processing of Linguistics has been enthusiastically championed by Pustejovsky (1995) predicting real-world benefits: 1)size reduction in dictionary storage –space/time parameters-, 2)efficient management of flexible senses generated "at the moment of use" and 3)state-of-

the-art grasping of adaptive non-standard senses in context (Pustejovsky, 1988; Pustejovsky, 1993b; Pustejovsky, 1995; Cowie, 2006; Ravin, 2000; Kilgarriff, 2001).

This dissertation advocates for an extended cognitive framework to outline the beneficial advent of a turning point in CL. Such turning point will enable linguistic studies being informed by computational tools to allow the full appreciation of the computational complexity of text corpora (Pustejovsky, 1995). Ultimately, there will be a better understanding of available large-scale lexical resources and on-line corpora (Pustejovsky, 1995; Agirre, 2006; Navigli, 2009).

A computational extension for SELs will improve highly impoverished coverage on the senses of several domains (Pustejovsky, 1995; Taylor, 2003; Agirre, 2006). The lack of interpretation of ambiguous nouns in composition in SELs has been hampering WSD and slowing down computational research of language studies (Pustejovsky, 1995; Resnik; 1995).

Automatic dictionary-based WSD had begun in the 1980's an explicitly important relationship between WSD and lexicography to unfold groundbreaking research (Agirre, 2006). As a result, noun compounding studies recently have outweighed difficulties in lexicography by significantly improving WSD (Pustejovsky, 1993a; Pustejovsky, 1995; Resnik; 1995; Agirre, 2006; Navigli, 2009;). The benefits from addressing automatic NC ambiguity are of paramount importance in fast-evolving web environments. Search tools are used to adapt the query formulation of users in terms of keywords or nouns. Ambiguous queries need therefore to be disambiguated for rewarding experiences (Pustejovsky, 1993a; Kobayashi, 2000; Shepherd, 2007).

1.3.4.Thesis layout

This section presents a bird's eye view of a research layout to reflect the work to be carried out. The following layout has divided the dissertation structure into

seven chapters, which are considered logically interconnected, due to the significant amount of interaction and deliverables involved.

From the remainder six chapters, some parts have been detached and allocated to the appendixes to facilitate the reading experience. Each chapter has been organised to reflect a procedural organisation. The parts of the methodology will be outlined and explained In Chapter 2 to reflect a self-explained methodological process. The Layout of the chapters is as follows:

- **Chapter 1- Background**: This chapter will outline a general introduction to address broad details surrounding NC ambiguity as well as its relationship to CL, followed by a research question. The background will cover the general aspects of the Cognitive Paradigm. These aspects will reveal areas of opportunity for the computational improvement of the cognitive framework called the Dynamic Construal of Meaning, and will help structure a research question about its "at the moment of use" meanings. Afterwards, the aspects in terms of the formulation of the aim of this research will be given. Computational capacities of the framework will be addressed by a general aim formulation. The resulting aim research will be broken down into a three-objective layout.

- **Chapter 2- Design Research Methodology**: This chapter will describe a research methodology approach to solving the above three-objective layout. Reviews on the methodology will clarify the Design Research (henceforth DR) processes to provide soundness of the methodological structure of this dissertation. The elements of the methodology will be introduced leading to Artefacts (henceforth terminology for Artefact with first letter in capitals)

and the key deliverables of this dissertation, which will help organise the planning. The present chapter will argue Artefact-intensive methods and its strengths, in order to explain the methodological relevance. A chart will be included to represent the linear procedures of the methodology at a well-known level of abstraction from the Vaishnavi's article (2004). The detailed structure of the chart will make use of all main phases as described in the Vaishnavi's survey (2004). This chart will provide the methodological guidance throughout this dissertation.

⌦ **Chapter 3- Literature Review**: This chapter will refer to key reviews in the literature about noun compounding and related topics. The Literature Review will be a process mainly supported by search and, extensively based on critical findings. This chapter will revise techniques surrounding noun compounding paradigms, bracketing, and noun paraphrasing mechanisms. The chapter will build awareness by drawing on existing theories of language –the GLT, and Cognitive Linguistics- and several language experiments in the Literature. Finally, the findings will be used in the next chapter towards problem-solving.

⌦ **Chapter 4 Artefact-intensive Processing**: This chapter will process the three main Artefacts of the DR Methodology: 1)Constructs, 2)Models and 3)Methods (March, 1995). The Artefact creation as the key task of the Methodology will involve concepts and relationships of concepts to structure the soundness and the internal logic of the Design D. The above key concepts will help assemble the most relevant Artefacts: 1)the Proposal and 2)the Tentative Design D. This

chapter will encompass construction cycles revealing the nuts and bolts of performance-improving and their implications for this dissertation. The Artefacts and deliverables of this chapter will realise the research objectives specified in Chapter 1.

⌦ **Chapter 5- Implementation**: This chapter will implement the Design of the Artefact D or the Tentative Design D –the AXEL System. The nature of the Artefact D will be that of a software application to carry out generative behaviours. The chapter will focus on the novelty of the solution, rather than the novelty of the construction approach. The details of the implementation related to the functional requirements will try to reflect an off-the-shelf approach to solving a problem. This assumption will therefore justify mildly pedestrian instantiations of the data interfaces, and the programming tools. Some testing will start at this stage by sense-tagging relations of the trainings set of a supervised approach.

⌦ **Chapter 6- Evaluation**: This chapter will evaluate the Artefact D developed in Chapter 5. Rearrangements on the test sets will be handled and sampled, in order to structure a valid supervised approach. The Artefact D will undergo a second iteration which will semantically prepare a heuristic hypothesis change. The nature of the change, however, will shorten the methodological cycle, resulting in a new Artefact D with an extended set of prepositional paraphrasing. The test exercises will be undertaken under exactly identical conditions of that of the first iteration, resulting in a second version of results. Both sets from the first and second

iterations will be used for comparison. The chapter will stress the experimental figures obtained from both tests.

⌦ **Chapter 7- Conclusions:** This chapter will analyse experimental results from Chapter 6 towards an outline of this dissertation's contributions. The three main conclusions will be formulated and the Artefact limitations will be singled out in future work. Also as part of a secondary set of contributions, the final Artefact will be delivered as a table of results, according to the present Methodology.

1.3.5. Chapter Summary

The work done throughout this chapter has primarily concentrated in addressing an initial knowledge structure that has led to a research opportunity. The background was succinctly covered in order to inform with a broad range of ideas, the details of the cognitive framework, the dynamic construal of meaning and its limitations. Such discussion helped open up a research area about noun in combination to include computational capacities. The aim of this research deployed the three objectives of this dissertation, which will solve the computational drawbacks of the dynamic construal of meaning. Finally the above layout outlined a structure that will guide the present research.

The next chapter will cover methodology issues, which essentially will allow for the organisation of the research planning.

2. DESIGN RESEARCH METHODOLOGY

2.1. DESIGN SCIENCE PROCESSES

2.1.1. Arguing the Strengths of Design Research

This chapter will approach the methodology process for this work, and will argue central strengths of the DR Science. Generally speaking, a methodology research is a set of steps reassembling a multi-stage process that must be followed to complete a research endeavour (Saunders, 2003). Essentially a Design research methodology is considered to be a means to handle a series of linked stages organised in a linear manner to contribute to the understanding of a phenomenon (Nunamaker, 1990; Vaishnavi, 2004).

Methodological distinctions in the level of abstraction between the artificial and the natural have led to two research typical approaches: Natural Science Design and the Science of the Artificial Design. Artificial intellectual levels of abstraction involve knowledge about manmade objects to readily change an existing state of affairs to a preferred one (Dasgupta, 1992; Bayazit 1993; Blessing, 2009; Vaishnavi, 2004).

The present methodology looks to carry the out creation of manmade objects in order to confirm/disconfirm a linguistic theory on lexical ambiguity. To this end, this work will adopt a Design approach to take advantage of methods and tools in Design, which ultimately support creation (Blessing, 1998).

A key benefit from DR methodologies is their review-based vs. comprehensive structures, which allows to breakdown complete research projects on demand. Unmanageable PhD projects can therefore be analysed and carried out in small studies.

Certain PhD research usually involves growing complexity in chains of causes, stages, processes, etc., which in the practice necessarily stops each DR step from

in-depth execution (Blessing, 1988; Blessing, 2009). A review-based study is supported by the review of the Literature only, while a comprehensive study includes review of the literature, and empirical efforts to develop products and evaluate results (Blessing, 2009).

Phases in some PhD projects are not necessarily comprehensive for certain purposes throughout research and can be regarded as initial or non-fully comprehensive due to either time restrictions or the planned scope of the project (Blessing, 1988, Blessing, 2009).

Some parts of the present methodology to be adopted here will rest upon this assumption of a review-based approach. Hence the present DR processes will make use of either comprehensive or review-based approaches to coping with the Artefact creation.

The flexibility of application Design outside traditional engineering is the main method's advantage to cope with symbolic processes and software development disciplines (Dasgupta, 1992; Nunamaker, 1990; March, 1995). There appear to be this flexibility of Design has led to frameworks of research that concentrate on different characteristics of Design (Bayazit, 1993; March, 1995; Vaishnavi, 2004; Blessing, 2009).

This work will adopt, however, a general enough DR Methodology by Vaishnavi (2004) to undertake the present research process. Vaishnavi's article (2004) will provide such a methodology guideline to document the DR processes of this dissertation in the next section.

2.1.2. Design Research Processes for this Dissertation

This section will explain DR methods used to create Artefacts complying with Vaishnavi's Design cycle (2004). The present DR cycle will involve iterations to allow for recurrent links back to some stages of the research (Vaishnavi, 2004;

Blessing, 2009). The DR Phases of this dissertation will be organised as follows according to (Vaishnavi, 2004): 1)Awareness phase, 2)Suggestion phase, 3)Development phase, 4)Evaluation phase, and 5)Conclusion phase.

Regarding the Suggestion phase, the Tentative Design will be characterised in terms of the notion of an Artificial Intelligence (henceforth AI) Paradigm describing the search for solutions in a problem space (Dasgupta, 1992).

This dissertation does not explain or expound tenets about the symbolic model in AI. It only assumes the discussion of a Design as a concise characterisation of AI will b extremely beneficial for Design representation. The Details and motivations about the consequences of revisiting the problem of Design as an AI task must be referred to Dasgupta's work (1992).

This present methodological approach will be detailed to formulate the Models and Methods describing the internal organisation of all five phases of Design, as follows:

- **1st Phase- Awareness of Problem**: This Awareness phase will deliver the Construct and Proposal deliverables. The phase aims to detail clarification about techniques to deal with NNNCs, namely bracketing techniques, appraisal of recursive constraints and analyse of syntax parameters. Literature review will then provide support to opt for a suitable paraphrasing technique, in order to model underlying relations for noun constituents. The phase will acquire the vocabulary to produce evidence about realistic performance-improving (Blessing, 2009). A Construct table will be the 1st deliverable, which will meet the 1st Objective. The DR Proposal will be the result of the interplay between relations

among Constructs –so called Models-, which will prepare practical solution efforts specifying key alliances between Constructs and Models (Vaishnavi, 2004; March, 1995). Performance measures will be agreed in the form of intermediate support to derive measures related to two-noun compounding, bracketing, and IOF and ODOF characterisation. Such a Proposal will deploy the 2nd deliverable. Relations between Artefacts will model the internal organisation of the operations in the computational framework to meet the 2nd Objective.

⌦ **2nd Phase- Suggestion**: This phase will report on a Tentative Design, which will be closely related to the Proposal. The Tentative Design will supply Construct-Model paths which will contribute towards a computational template –the 3rd deliverable- via procedurally ordered Methods to convey a Tentative Design D (Dasgupta, 1992; Bayazit, 1993).The Methods will address interactions and collaboration between lexical hierarchies, type inheritance, prepositional semantics, and recursive noun compounding. An AI characterisation of Design D or Artefact D will conduct the efforts to build a Design D to meet requirements R (Dasgupta, 1992). The Design goal of this phase will be seen as evolving an initial state S_0 to a goal state S_g. When reached, this solution will constitute the Design D –ordered set of Methods- which satisfies the requirements R. The 3rd Objective will be met.

⌦ **3rd Phase- Development:** This phase will build an instance of the Design D or the template called the AXEL System -the 4th deliverable. Some considerations on

application architecture will determine data exchange modes of the program. Due to time restrictions some interfaces in the AXEL system will be manually provided. This approach will be established as a review-based study towards a semi-automatic API exchange with the knowledge database. The functional requirements of the AXEL System will be specified by use of UML language -Use Cases- diagrams. Evaluation Phase will start at this stage, by manually tagging sense-annotated tables by Girju (2009a). This approach will be a review-based development, as it does not build and assess automatic interfaces with the knowledge base, nor does it thoroughly sense-tag the training set for testing (Blessing, 2009).

⌦ **4th Phase- Evaluation**: This phase will undertake full assessment of the AXEL System. There will be two orders of things that will unfold. First, the organisation of the testing procedure deployed as a supervised approach. According to a review-based resource in the Development phase for Girju's tables (2009a), the training set had already been manually analysed in the Development phase. Secondly, the test set will rearrange Lauer's sets (1995a), in order to supply suitable scenarios for recursive compounding, at NNC and NNNC levels. Practical evaluation –the 5th deliverable- will lead to experimental results for both NNCs and NNNCs. The assessment of the Performance Criteria will lead to a second sub phase in the DR cycle. A second iteration will reassess hypotheses about utility of semantic rules to attempt performance improving (March, 1995; Winter, 2008; Vaishnavi, 2004). This will generate a second version of the AXEL System –the 6th deliverable-, which will undergo full

testing again. The second iteration will leave the Design unchanged leading to a new Use-Case diagram.

⌦ **5th Phase- Conclusion**: This phase will reflect on an overall research cycle and its findings on tractability of computational efforts as well as objectives achieved. A table –the 7th deliverable- about the major contributions will be discussed to confirm successful Artefact creation (Blessing, 2009).

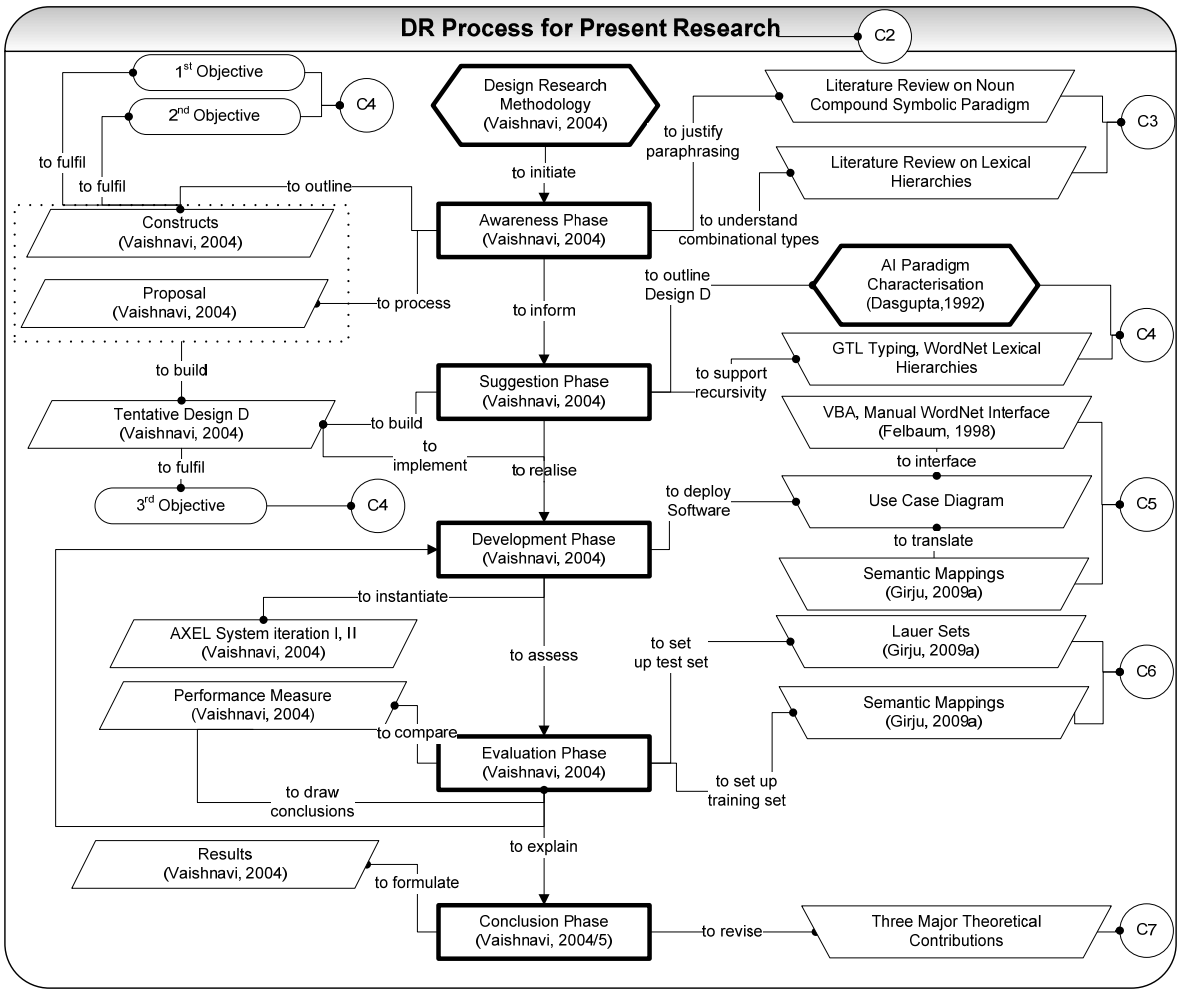
In assisting the reading of the diagram below, symbols will be explained. The diagram openings start with the hexagram "Design Research Methodology", and from that point on, it will flow down until it is finished in the rectangle "Conclusion Phase".

A rectangle represents a DR phase; whereas, the hexagram represents a methodology. The bold lines mark methodological approaches. For example, the diagram utilises two methodological strategies, DR itself and a mild flavour of AI Paradigm.

Ellipsoids represent objectives. Circles represent chapters of this dissertation at which processes are taken place. Trapezoids enable representation of tools and techniques fulfilling a purpose, while parallelograms allocate deliverables of this dissertation.

Connecting lines are divided into labelled lines with arrow heads and labelled lines with rounded ends. The former represents flow of the set of processes throughout research. The latter represents interrelations between objects.

The diagram below will describe the research flow of the DR processes:



vi. Figure showing the DR process methodology for the present research.

2.1.3. Iterations in the Present Design Research Process

Intuitively the DR methodology enables flexible management of iterations in order to increase its Design potential (Blessing, 1988; Saunders, 2003; Vaishnavi, 2004; Blessing, 2009). It is claimed that flexible methodologies can boost Design and build overall robust theories of Design (Blessing, 2009).

This above key characteristic is the reason why this dissertation planned a variation of the AXEL System. Such a flexible approach will involve a second version of the AXEL System unlocking the flexibility of this research to increase expressiveness and benefits of Design Methods. The realisation of iterations has

been graphically depicted in above chart vi for the processes of the methodology. It can be seen the arrow going out of the Evaluation phase links back the flow of the diagram to the Development phase.

Changes in the semantic mappings will be detailed and explained at the end of the first iteration in Chapter 6. As a result, the processing flow will imply changes at the stage of semantic mappings in Girju's works (2009a), leaving the Design D therefore unchanged in the Suggestion Phase. It can be seen the main arrow re-entries the diagram in the Development phase. From that point on, each subsequent stage will be revisited to affect the Development and the Evaluation phases only.

The trapezoid "AXEL System Iteration" in the iteration cycle contains two AXEL Artefacts to represent deliverables from the Development phase. Hence the methodology deliberately leaves the Design D unchanged due to the planned flexibility approach to performance-improving.

The next chapter will carry out the application of the processes of the present methodology. The diagram vi will therefore be used as a quick reference to the methodology processes everywhere throughout this dissertation.

3. LITERATURE REVIEW

3.1. AWARENESS ON NOUN COMPOUNDING

3.1.1. Introduction

The present chapter will revise the Literature to gain in-depth awareness about noun compounding interpretation and related conceptual combination. Noun compounding vibrancy has already been acknowledged in Pustejovsky's findings (1995), which have been touted novel in dealing with so called logical polysemy[1]. This literature review aims to link syntactic parameters, lexical hierarchies and type inheritance notions of "the hard part" of the dynamic construal of meaning.

The relevance of a coherence picture of collaboration between syntax and semantics will surface in the identification of domain vocabulary. Overall, this chapter will outline research contributions about noun constituent semantic relations (henceforth SR), bracketing, recursive approaches to superior compounding, paraphrasing, syntactic elements and lexical hierarchies to clarify goals towards Construct formulation.

3.1.2. Compositional Nature of Noun Compounds

A great deal of controversy arises when researchers try to agree on the nature of a NC within the broad class of nominal expressions (Malmkjaer, 1991; Fabb, 1998; Bauer, 2006). There are a number of criteria in use to classify NCs, ranging from orthographic, morphological (Krovetz, 1987), syntactic, semantic and even phonological criteria (Sproat, 1987; Bauer, 2006). However, research publications have consistently privileged semantic and syntactic characterisations in understanding NPs, due to the major fact that NNC interpretation arises through the productive use of syntactic rules (Bauer, 2006).

[1] Logical polysemy studies alternations in meaning of nouns ensuring noun category preserving (Pustejovsky, 1995).

Understandably it has not been agreed a common compounding nature as yet. Some researchers do not study NNC structures alone and consider them irrelevant for certain purposes admitting the use of any adjective-noun or general modifier-noun in NPs, i.e. any open-class specifier (Barker, 1998a; Barker, 1998b; Moldovan, 2004b; Abdullah, 2007). However, noun-specific relations have posed noun elements as capable of truly correlating semantics of compounding productivity rules (Finin, 1980; Rosario, 2001; Lapata, 2000; Girju, 2005; Nicholson, 2005; Nakov, 2005; Tribble, 2006; Costello, 2006; Kim, 2007; Kim, 2008; Nakov, 2008a; Nakov, 2008b; Nicholson, 2008; Girju, 2009a; Girju, 2009b).

Certain NCs however have limited the productive rules of compositional syntax and semantics in compounding. For instance, so-called opaque NNCs are unrelated to noun constituents resulting in meanings not being derived from the participating nouns (Barker, 1998a; Barker, 1998b; Baldwin, 2004; Moldovan, 2004b; Girju, 2005; Tribble, 2006; Abdullah, 2007). Opaque or lexicalised NCs are highly idiomatic and convey non-compositional meanings. For instance “guinea pig” is one NC that does not have direct relationship to “guinea” or “pig” whatsoever (Barker, 1998a).

Mainstream approaches to lexicalised NCs advocates for avoiding them to stop inconvenient structures that are not governed by compositional rules, and deviate from typical NNC compositionality (Barret, 2001; Barker, 1998a; Barker, 1998b; Tribble, 2006; Baldwin, 2004; Moldovan, 2004; Abdullah, 2007; Tribble, 2006). Lexicalised NCs are less numerous in current dictionaries representing therefore no critical factor for understanding compositional NC theories (Abdullah, 2007).

This review-based evidence on NC structure argued that noun constituent compositionality involving syntactic and lexical semantic elements is critical to understand productivity and ambiguity in noun compounding.

3.1.3. Recursive Approach to Higher-arity Compounding

Studies of NCs have hinted semantic and syntactic elements will reveal factors to underpin Construct development. In this section this Literature Review will investigate issues on the length of noun compounding and the effects on computational tractability.

For the vast majority of NC publication, research has focused on NNC structures only –there is a good reason however, this review will find out -, and has not attempted to readjust research efforts to solve superior NCs (Finin, 1980; Lapata, 2000; Barret, 2001; Baldwin, 2004; Moldovan, 2004; Nicholson, 2005; Tribble, 2006; Nakov, 2008a; Nakov, 2008b; Kim, 2007; Kim, 2008a). Such state of neglect is of course not incompetence, but an account of how extraordinarily complex the nature of noun compounding is in spaces with more than two nouns (Finin, 1980; Lapata, 2000; Barret, 2001; Rosario, 2001).

The complexities in NNC interpretation that pose difficulties are: 1)noun constituents involve virtually unleashed productivity, 2) noun constituents present implicit relations, and 3)the compounding interpretation is heavily influenced by context (Finin, 1980; Lapata, 2000; Baldwin, 2004). Moreover, NNNCs or superior NCs face an extra computational difficulty called bracketing, which poses hard tasks to define left versus right association of pairs of noun constituents (Rosario, 2001).

Of course the earliest research concentrated on binary analyses of the above complexities in two-noun spaces only (Li, 1970 in Downing, 1977; Levi, 1974 in Downing, 1977; Downing, 1977). Likewise, Cognitive Science guided by experimental interests abounded with NNC experiments only (Wisniewski, 1998; Costello, 1996; Costello, 2002; Gagné, 2002; Lynott, 2004a; Costello, 2006; Maguire, 2007; Choi, 2007; Maguire, 2010; Zlatev, 2010). This is to say, theoretical structures of higher-arity compounding were held back in CL and only started emerging at a later stage progressively.

Conceptual combination has not evolved into approaches to higher-arity compounding. Instead, conceptual combination has shifted empirical interest to investigate evidence on understanding how people combine noun templates to explain novel NNCs (Costello, 2002).

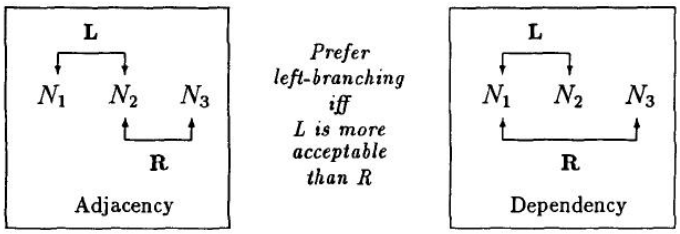
However, interest in superior compounding started spawning and were grounded in computational needs and technology-driven necessities for covering interpretation in neglected domains, namely management of Bioscience text in medical domains (Nakov, 2005), querying of user manuals in the engineering field (Isabelle. 1984), and WSD work supporting software on technological systems specifications (Arens, 1987).

Research has evolved ever since to critically revised ideas about higher-arity compounding much more consistently (Isabelle, 1984; Arens, 1987; Lauer, 1995a; Barker 1998a; Girju, 2005; Nakov 2005; Vadas, 2007). Each work has virtually used a very different approach though, in solving higher-arity compounding. NC parsing –bracketing- has surfaced as a key element which has been repeatedly revisited. Undoubtedly bracketing surpasses still nowadays the importance of other semantic subtasks in higher-arity compounding and is touted initial commonplace of any serious approach (Lauer, 1995a; Barker, 1998b; Girju, 2005; Nakov, 2005; Vadas, 2007).

For instance, Barker's approach (1998b) aimed, in the first place, at breaking down NCs into pairs of nouns, then proceeding with interpretation of SRs among individual pairs of components. Girju (2005) planned the same course of action: bracketing followed by automatic annotation of semantic categories for each pair of noun constituents.

Even more, Lauer reported on groundbreaking bracketing approach that evaluated the most likely bracketing by computing either leftmost adjacent nouns, or first and

third nouns. Lauer's approach was called the Dependency model as opposed to the Adjacency Model. Adjacency was outlined in the GLT towards computational techniques of lexical analysis, and basically plays an oracle qualifying contiguous sequences of NCs (Pustejovsky, 1993a).



vii. Figure for describing two analysis models to characterise branching theory, taken from (Lauer, 1995b)

Rosario (2001) indentified the choice between left versus right association in bracketing as a goal standard approach to learning how to select right from left split in compounding, one way or another (Lauer, 1995a). However, a long-standing weakness to probabilistic bracketing is data sparseness. These techniques very often fall short from exhaustively parsing text corpora, especially large corpora. Moreover NCs are rare across the corpus and then so infrequent, that probability estimates are unreliable leading to wrong parsing choices (Girju, 2005).

Probabilistic bracketing might not substantially outperform a monotonous left-branching choice for certain purposes and within specific corpora. Lauer (1995b) reported on outstanding 77.5% of accuracy in bracketing prediction with his adjacency model. This is to say roughly Lauer's model picks 7 out of 10 right parsed splits. However, Barker (1998b) has reported figures on left-branching methods on NNNCs ranging between 60% and 70% accuracy. This is to say apparently 7 in 10 NNNCs in language are characterised as left-branching parsing.

Either way, bracketing has been catapulted into the limelight of NLP, attracting an unprecedented deal of attention. However, it is half way higher-arity compounding understanding, since higher-arity semantic interpretation needs to be dealt with.

The constructive approach pointed out that Selkirk's recursiveness is to provide universal solutions towards understanding long sequences of compounds. Girju (2005) has applied Selkirk's ideas in order to deploy recursive state-of-the-art applications to approach three-noun compounding. Lauer (1995a) has argued a similar approach to multiword structures assuming each relationship from bracketing behaves exactly as it would in NNC structures.

Remarkably a few researchers have explicitly attempted both bracketing and NNC interpretation approaches to dealing whit long sequences of nouns, (Barker, 1998a; Barker, 1998b; Vadas, 2007). This Literature Review argues the following reason. Simultaneous bracketing and recursive NNC interpretation in a conceptual space with more than two nouns are an exceedingly difficult task (Fining, 1980).

This Literature Review section was aimed at disclosing clarification about approaches to superior compounding by identifying two pivotal tasks: 1)bracketing and 2)recursive NNC interpretation. The findings from the present Literature Review acknowledged that any approach to understanding higher-arity noun compounding is based on parsing followed by recursive NNC interpretation.

3.1.4. Computational Criteria for Paraphrasing

This section will attempt to disclose details on understanding how underlying noun constituent relations informed the theory and affect computational affairs.

Strikingly common, on one hand, patterns to determine SRs between noun constituents have been translated into probabilistic models (Lauer, 1995a; Lapata, 2000; Nicholson, 2005). On the other hand, solutions have ranged in the symbolic paradigm, which makes extensive use of dictionaries -knowledge bases-, relying primarily on encoded semantic information (Finin, 1980; Barker, 1998a; Costello, 2002; Baldwin, 2004; Moldovan, 2004b; Kim, 2005; Nakov, 2006; Tribble, 2006; Kim 2007). Following on there is a painstakingly selection of set of rules to play

around with this semantic information in order to come up with NC interpretation (Lapata, 2000).

However, knowledge-based sources are not free of contradictory views in NC prediction; the problem of choosing a symbolic paradigm has been visited quite often indicating it is a worthwhile way of explaining properties of NCs (Levi, 1975 in Downing, 1977; Girju, 2009b; Rosario, 2001). Analysis of mainstream methods in the literature has confirmed the problem remains in determining what the best kind of underlying relation is (Rosario, 2001).

In the symbolic arena, high-profile criteria to opt for the best set of rules are implicitly centred on set size. To begin with, small-sized set approaches argue the existence of a reduced collection of SRs that many NCs might imply (Levi, 1975 in Downing, 1977; Lauer, 1995a). Quite the opposite, methods bound to an infinite number of SRs argue that no finite or small listings can account for the complexities of interpretation between noun constituents (Downing, 1977; Finin,1980; Nakov, 2008a; Nakov, 2008b). In between these two extremes lies the approach that advocates for medium-sized collections, usually ranging in the dozens (Rosario, 2000; Moldovan, 2004; Girju, 2005; Girju, 2009a). Although the appropriate number of SRs has not been widely agreed upon, ongoing debate demonstrates that it is worth revising in order to gain awareness in the interests of computational applications and tractable computing (Pustejovsky, 1995).

The most famous documented infinite-sized approach dates back to Downing's work (1977), who argued no detailed NC relation can be characterised in terms of a finite list of "appropriate compounding relationships" (Downing, 1977). This approach was a reaction to semantics of primitives, clamming small sets could not account sufficiently for NCs interpretation. Even more Downing (1977) criticised doubtful vagueness in NC characterisation and disallowed misguiding sets of semantic primitives. Later on, views on infinite listings unfolded into theoretical verb

paraphrasing referring to abstract tasks of generating an inventory of all possible verbs to approximate the semantics of a NC (Nakov, 2008a).

The next approach to finding the ideal set of SRs was based on NC interpretation in terms of verbs, where the head noun was a nominalised verb (Lapata, 2000). From that point on, the theoretical nominalisation of noun constituents related to nominalised verbs has enthusiastically amounted to thousands of very specific SRs (Finin 1980; Girju, 2005). The benefits of extending infinite-sized solutions argue better semantics to approximate NC interpretation.

However, from a computationally tractable point of view this approach violates a feasible system implementation and makes it practically unachievable. Pustejovsky's generative program (1995) turns to solve limitations of SELs by avoiding sense storage in dictionaries, due to impoverishment of weak compositionality (Pustejovsky, 1993b; Pustejovsky, 1995). In sharp contrast, Downing (1977) advocate for a return to all senses a NC might have to be stored as "permanent, non-predictable" paraphrasing, which is a sad state of affairs for computational endeavours (Pustejovsky, 1995).

Lying on the lower extreme of the size-based continuum, preposition-based approaches constituted themselves into influential views on NC semantics. Small preposition sets aims at paraphrasing economical relations in NCs. Levy's work (1978 in Lauer, 1995a) pioneered the most endurable approach so far to prepositional paraphrasing, arguing Recoverably Deletable Predicates (henceforth RDPs) were able to express the semantics vast majority of NCs may imply, for example, "pie made of apples" turns into "apple pie" via RDPs (Lauer, 1995a).

This approach claimed it could provide semantic primitives to compose meaningful paraphrasing for a great number of NCs, alternatively to unmanageable infinite semantics. The first Levi's set was a mix of RDPs and prepositions which started out as a seven-member table, increasing over time to a twelve-predicate table

containing 4 prepositions only (Levi, 1978 in Downing, 1977). Over time, the preposition outlook over semantics became fast-changing in order to cope with shortcomings about potential ambiguity of NC. Terms of this positive evolution reflected an increase in prepositions, amounting to 8 in Lauer's research (1995a).

DELETED PREDICATE	N+N	ADJ+N
CAUSE	battle fatigue	viral infection
	disease germ	malarial mosquito
HAVE	snake poison	reptilian scales
	apple cake	musical comedy
MAKE	cellblock	floral wreath
	silkworm	sebaceous glands
USE	steam engine	electric drill
BE	girlfriend	professorial friends
IN	fieldmouse	polar bear
FOR	bird sanctuary	avian sanctuary

RDP	Example	Subj/obj	Traditional Name
$CAUSE_1$	*tear gas*	object	causative
$CAUSE_2$	*drug deaths*	subject	causative
$HAVE_1$	*apple cake*	object	possessive/dative
$HAVE_2$	*lemon peel*	subject	possessive/dative
$MAKE_1$	*silkworm*	object	productive/composit.
$MAKE_2$	*snowball*	subject	productive/composit.
USE	*steam iron*	object	instrumental
BE	*soldier ant*	object	essive/appositional
IN	*field mouse*	object	locative
FOR	*horse doctor*	object	purposive/benefactive
FROM	*olive oil*	object	source/ablative
ABOUT	*price war*	object	topic

viii. Figures representing first Levi's set of Recoverably Deletable Predicates -left- which evolved into a 12-predicate table -right- to limit potential ambiguity of NCs, taken from (Downing, 1977; Nakov, 2008a)

However a preposition's potent succinctness could result in computational benefits, as it claimed preposition compatibility is at odds with preposition classes accounting for all occurring compounds in the lexicon (Downing, 1977). In brief, complaints and negative remarks about preposition-based approaches draw on lost meaning (Girju, 2005).

Despite drawbacks in unambiguous interpretation, quite recently preposition approach has been touted a fine ally in dedicated workings on CL topics towards NC interpretation, despite criticism over vagueness and its underserved "rank of stop word". Furthermore, no doubt preposition-based methods have helped NLP applications to bridge language understanding in CL (Warren, 1978 in Lauer, 1995a; Levi, 1978 in Downing, 1977; Lauer, 1995a; Johnston, 1996; Barker, 1998a; Baldwin, 2009; Girju, 2009a).

More important however, computationally speaking, small sets of SRs put tractable computing at ease (Pustejovsky, 1995; Lauer, 1995; Barker, 1998a). A cross-linguistic analysis was performed by Girju (2009a) providing mappings between prepositions and abstract SRs, paving the way to promising computational interpretation of NPs –NN and NPN- in English in the future (Girju, 2009). Similarly

Johnston (1996) utilises cross-linguistic information based on prepositions mappings to boost a generative device for revealing the otherwise implicit relation between noun constituents of English NCs. Lauer (1995a) trained a novel statistical framework resting upon preposition-based paraphrasing to solve NC interpretation with a state-of-the-art statistical learner. Barker (1998a) built a system for recognition of relationships between elements of NPs by extracting and processing information in terms of prepositions, nouns and adjectival tokens. The main remarks were made on advantages of having a manageable computational dictionary of prepositions, which expedites the data crunching straightforward.

In between the two extremes lies a moderate approach to NC interpretation, which has caught computational linguists' attention. Medium-sized sets of abstract predicates started out as a computational reaction to boundless solutions. Basically SRs have accounted closely for templates of interactions between head noun and modifier nouns, assigning interpretation to concepts derived from nouns (Finin, 1980). Abstract predicates or SRs occurred between noun constituents expressing binary paraphrasing in terms of various syntactic levels of abstraction, like possession between two entities, property as quality, location or spatial relation, etc. (Moldovan, 2004b)

The SR approach finds very useful extracting predicates based on lexico-syntactic patterns from on-line dictionaries, like WordNet (Kravetz, 1987; Moldovan, 2004b; Kim, 2005; Kim, 2007; Costello, 2006; Kim, 2008). Such method is an exemplar of symbolic paradigm that embodies clearly knowledge-based algorithms addressing underlying SRs for NC interpretation.

Of course, computational linguists therefore show vibrant interest in applying and studying structural motivations about SRs. However, no interest surfaces to understand the empirically cognitive motivations of relations, resulting in unstable sets of prepositions. For instance, Moldovan and Girju (2004b) manage a long 35-relation instrument that has been fine-tuned over several years of critical revision

and readjustments, evolving into a shorter set of 22 SRs (2009a). Barret (2001) exploits heuristics and reported on an unfinished set of 25 SRs to be continued. Rosario (2001) focuses on 38 SRs of her own reacting to inappropriateness of others' tables. This emphasises a troubled approach to no obvious set of distinctly ideal set of relationships.

Another objection to an ideal set of SRs is probably its domain-dependant nature. SRs in a domain might not be aligned in some other domains. Girju's cross-linguistic mapping (2009a) showed that a few SRs in the Europarl corpus did not appear in the CLUVI corpus, for instance SOURCE SR (Girju, 2009a, p. 202). A sought-after set of relations has not been proposed yet in the Literature due to highly application-dependant and highly domain-dependant effects (Barret, 2001; Rosario, 2001; Girju, 2009a).

Vagueness in SR classification still holds to the extent that has been constantly noticed that SRs can lead to multiple category-filling interpretation –Cell Growth is both Activity SR and Change SR (Rosario, 2001). Cognitive linguists have critically studied this ambiguous phenomenon and have attempted to draw frontiers in understanding relations used in conceptual combination, resulting in confirmation that the human mind does not chose one but several SRs for a given NC (Devereux, 2005). Even more, Cognitive linguists have empirically appraised conceptual combinations and showed the human mind is not SR-prone, but actually chooses overtly different relational links between noun constituents (Wisniewski, 1998; Lynott, 2004a).

Computationally speaking, this approach is manageable in sharp contrast to the infinite-sized approach for obvious reasons. However it keeps a safe generative model at bay. Variability in the size and form of the SR set, amid effects of context-dependent biases, converts the hard part of the Dynamic Construal of Meaning –lexical semantic content retrieved from a knowledge base- into the soft part of the

Dynamic Construal of Meaning –flexibility of meaning to be generated "at the moment of use" (Croft, 2004, Cruse, 2001) .

This section reviewed a computational approach to finding an ideal set of SRs to account for NC interpretation successfully. Computationally speaking, the analysis reveals another level of reflexion about NC interpretation, which informs the problem of choosing the best set of relations in the Symbolic Paradigm.

The above review-based analysis outlined that an infinite-based set of SRs is computationally intractable and holds back a generative view. However, a medium-sized approach is computationally manageable, it is problematic due to the lack of consensus about the ideal set of SRs and the violation of empirical confirmation about dominantly unique SRs. Computationally speaking, a small-sized set proved undoubtedly tractable. Preposition paraphrasing complies with a computational view, which dispels the need of using large structures in lexical storage. The soft part of the Dynamic Construal of Meaning or flexible "at the moment of use" meanings is addressed (Croft, 2004; Cruse, 2001), which, in turn, is a fortunate state of affairs for a generative effort (Pustejovsky, 1995).

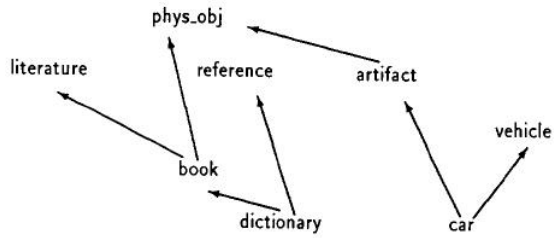
In the next section, this dissertation will discuss a general view of type inheritance in the GLT and its relation from a syntactic point of view to the theory of association of word senses.

3.1.5. Syntax-driven Elements

A major approach into semantics theory throughout the XX century has been championed by the Prototypical Theory from Cognitive Linguistics (Lakoff, 1987; Ravin, 2002; Croft, 2004; Geeraerts, 2006). The Prototypical Theory rests upon the Aristotelian hierarchical system to organise characteristics of nouns conceptualising knowledge of the language. Similarly Pustejovsky's theory parallels Classical hierarchies to conceptualise internal levels of interaction of nouns revisiting Aristotle's hierarchies (Ravin, 2002; Pustejovsky, 1995).

Remarkably both the Prototype Theory and the GLT share an identical system of lexical hierarchies underpinning both frameworks to represent semantic knowledge (Ravin, 2002). This is an immediate connection between the two.

The GLT levels of word representation in lexical phenomena rely on Argument structures to enable syntactic realisation of a word (Pustejovsky, 1993b; Pustejovsky, 1995). An Argument structure allows inclusion of noun properties at a level of syntax enabling them therefore at a level of semantics specifying what nouns are typed as, namely, simple, unified or complex types (Grimshaw, 1990 in Pustejovsky, 1993b; Pustejovsky, 1995). A GLT Argument representation draws heavily on references to a type or lexical hierarchy in orthogonal lattices activating different noun aspects by projecting particular lexico-conceptual inheritance relations via contextual factors “at the moment of use” (Pustejovsky, 1995; Croft, 2004; Cruse, 1993).



ix. Figures depicting a conventional representation of inheritance relations, taken from (Pustejovsky, 1993b)

The type lattice theory by Copestake (1991 in Pustejovsky, 1995) formalises the type characteristics of a noun within a GLT hierarchy system. This way it extends simple inheritance with a model of orthogonal inheritance. Following inheritance extension, the type hierarchy will only allow orthogonal types to merge into unified types (Pustejovsky, 1995).

The GLT provides a formal account of typing or unification of hierarchies resulting in type inheritance projections (Pustejovsky, 1995). Whereas hierarchical views of the dynamic construal of meaning framework represents the structural part of nouns in combination, specifically hyponymy/hypernymy sense relations (Croft, 2004).

This way, the GLT type inheritance and the structural components of the Cognitive Theory share lexical hierarchies to represent semantic knowledge about nouns. Despite collaborative syntax between the two, cooperation has been a widely debatable issue (Willems, 2006). This review argues that this is an implicit connection between the two theories. This connection could enable syntactic elements in the Dynamic Construal of Meaning framework to map semantics. Ontologically distinct components of nouns can be therefore explained in terms of lexical hierarchies towards association of noun meanings (Croft, 2004; Cruse, 2001).

How concepts integrate is still an active field of research in Cognitive Linguistics, which has resulted in various proposals of mental models to represent SRs between nouns (Costello, 1996; Wisniewski, 1998; Wilkenfeld, 2001; Costello, 2002; Gagné, 2002; Croft, 2004; Lynott, 2004a; Devereux, 2005; Costello, 2006; Maguire, 2007; Choi, 2007; Maguire, 2010).

How nouns actually prioritise elements of conceptual combination has fuelled research in Cognitive Linguistics spanning decades of efforts to understand mechanisms of noun composition (Smith, 1984; Lakoff, 1987; Costello, 1996; Wisniewski, 1998; Wilkenfeld, 2001; Costello, 2002; Gagné, 2002; Lynott, 2004a; Devereux, 2005; Costello, 2006; Maguire, 2007; Choi, 2007; Maguire, 2010; Zlatev, 2010).

An interesting approach to noun compounding by the dynamic construal of meaning proposes that association of concepts relies on lexical hierarchies of word senses to explain the degree of neighbouring collaboration of word meanings (Croft, 2004; Cruse, 2001). Many word meanings appear in an association between ontologically distinct components -lexical hierarchies- interacting to form progressively complex components (Smith, 1984; Croft, 2004). Croft (2004)

suggests associated meanings can structure a theoretical space constituted by two dimensions: 1)integration of meanings and 2)ontological distinctness of meanings.

Intuitively, association characterises variation of degree as follows: with reduced integration, polysemy senses arise; with increase integration components lose their autonomy. On the other hand, a reduction of ontological distinctness leads to a loss of autonomy; whereas, an increase in ontological distinctness favours a polysemic behaviour (Croft, 2004; Cruse, 2001).

The above association theory is not thought as a large-scale algorithm and its computational accounts are essentially unknown However, research on experimental language models has seriously undertaken software implementation to confirm/disconfirm ambiguity theories (Lynott, 2004a; Costello, 2006).

Lynott (2004a) has advanced a computational implementation of a mental model on how to constraint conceptual combinations, generating combining predicates of NNCs, in all possible ways. His system uses several types of constraints to dictate the acceptability of the generated interpretations. Lynott's method (2004a) plays a key role in computational applications by bridging Cognitive Linguistics and CL.

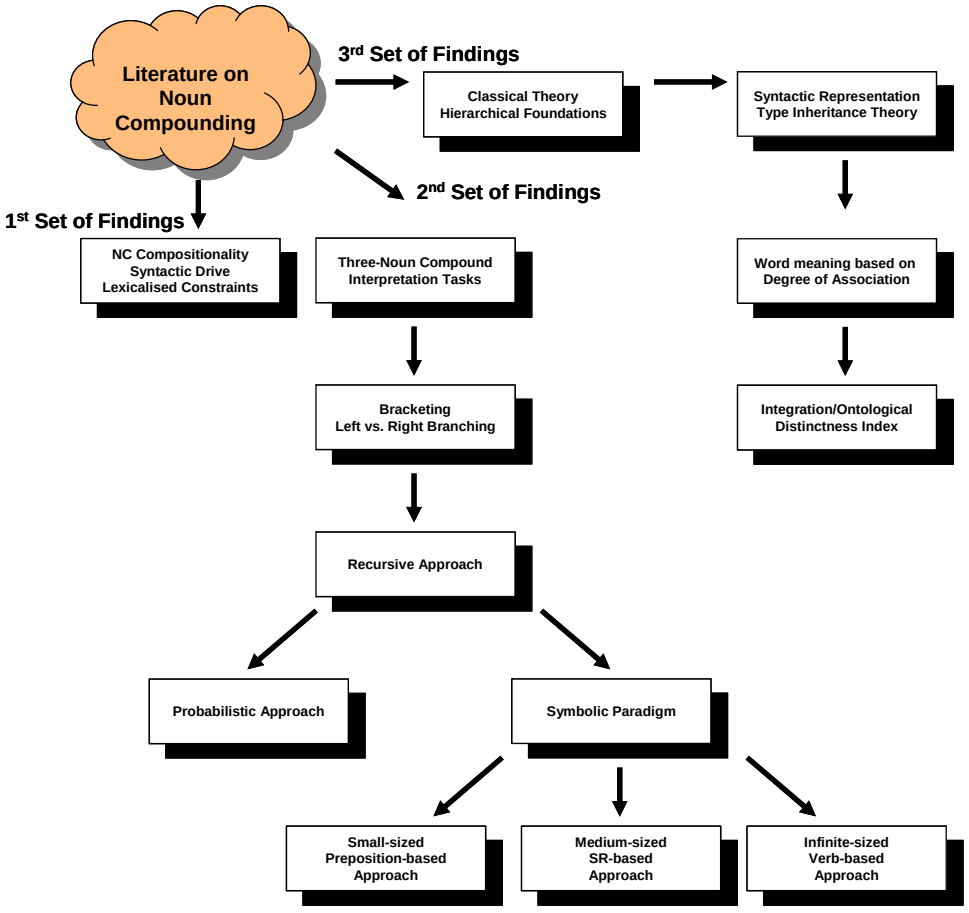
Similarly other efforts have taken advantages of knowledge-based approaches incorporating type inheritance parameters similar to those of the GLT (Costello, 2006). Costello (2006) searched an electronic lexical database -WordNet- to operate hypernym matches, delivering the most suitable NC interpretation.

Attempts to inform Linguistics with computational efforts is not new and has had the surpassing effect of accounting for hidden structures in the language (Lynott, 2004a; Costello, 2006; Pustejovsky, 2005). Computational efforts to acquire lexical information from large-scale text corpora has resulted in linguistic applications discovering semantic patterns with the use of software tools (Pustejovsky, 1993a; Sanfilippo; 1994; Johnston, 1996; Caudal, 1998)

This section has reviewed the use of lexical hierarchies to provide links between both language frameworks –the experimental and the formal-, otherwise traditionally opposing (Willems, 2006).

3.1.6. Chapter Summary

This section will summarise found evidence to back up research attempts towards identifying Constructs as data blocks of modelling. The Literature Review has intended pinpointing the main critical factors about the complex task of NC interpretation. The diagram below describes findings to prepare a possible course of action.



x. Chart representing findings of Literature Review.

Clouding in the diagram represents revised sources of knowledge. Arrow flow and rectangles in the diagram do not imply strict cause-effect relations, but generally dependent findings.

The first set of building blocks above showed surfacing characteristics constraining productivity rules in order to understand compositional NC processes. The findings confirmed NC processing is not totally unconstrained and needs to be understood (Downing, 1977). The revised Literature ruled out representations of lexicalised NCs due to the lack of compositional interplay, which made them irrelevant for the present research.

The second set of rectangles has organised the main findings linked to paraphrasing tasks of NC interpretation. It was revealed higher-arity NC interpretation ordinarily encompasses the process of bracketing and recursive mechanisms of semantic interpretation. Bracketing along with recursive NC interpretation has proved exceedingly difficult, which explains the shortage of efforts to solve the whole cycle (Lauer, 1995a; Vadas, 2007). Bracketing tasks concentrates on left versus right branching splits (Rosario, 2001; Vadas, 2007). The constructivist universal theory for NC interpretation of higher-arity compounding hints recursive strategies to approach NNNCs (Lauer, 1995a; Girju, 2009a).

Following bracketing, NNC semantics appears to be the second task to deal with. Implicit relations between noun constituents are not unproblematic since they form a continuum of choices, from a small to a very large set of relations. The computational advantages based on tractability have risked controversy about superiority of preposition-based approaches. However, competing symbolic approaches –SR approach and Verb-based interpretation- did not comply with tractable outlooks whatsoever, because of impending computational failures.

The third set of boxes explained how Semantics is realised by syntactic parameters to interpret association of noun meanings. Syntax was privileged in the GLT by outlining rich elements of type inheritance. The analysis disclosed the existing links between lexical hierarchy systems underlying both theories, the GLT and Cognitive Linguistics. Such common Aristotelian principles enabled the lexical hierarchies to integrate the syntactic elements into the Dynamic Construal of Meaning in order to account for computational association of nouns in combination (Croft, 2004).

The Dynamic Construal of Meaning provided a model for explaining association of noun meanings via two parameters: 1)integration and 2)ontological distinctness. However, its lack of computational drive did not discourage a promising implementation whatsoever. On the contrary, it hinted tractability.

The next chapter will draw on findings to lead Artefact-intensive phases to deliver a computational template for the Dynamic Construal of Meaning.

4. ARTEFACT-INTENSIVE PROCESSING

4.1. CONSTRUCTS, MODELS AND PROPOSAL

4.1.1. Introduction

This chapter delivers the main collection of Artefacts as sequence of Constructs and Models to help build in a procedural fashion the solution statement of the original problem (Bayazit, 1993).

To this end, Constructs and Methods will collide into a Proposal to document conceptualisation of a solution along with some performance measures. Following the Proposal, a Tentative Design D or Artefact D will assemble an ordered collection of Methods resulting in a computational interplay of Constructs and Models. To achieve the Artefact D, a notion of the AI paradigm implementation by Dasgupta (1982) will guide creation.

Dasgupta's contribution is not discussed here in this dissertation and consequently any in-depth enquiry must be referred to the original journal article (Dasgupta, 1982).

4.1.2. Constructs

Constructs will aim to provide clarification of goals from the Literature Review. To this end, the Construct Artefact –Constructs- will develop conceptual vocabularies to represent underlying relationships between findings in Chapter 3.

The Awareness phase has learned the interpretation of higher-arity compounding will involve both tasks, bracketing and recursive Symbolic Paradigm interpretation. In general, the evidence collected will help indentify a requirements R set for the project.

This dissertation is interested in automatically disclosing lexical information about ambiguity, rather than focusing on the effects of guessing right versus left associations in NCs (Rosario, 2001). To this end, the computational template will focus on left-branching parsing only. At the same time, the computational template intends to account for recursive approaches to higher-arity compounding, which will shift the attention to the minimum length of superior NCs.

The latter characteristics altogether will define the present review-based scope, which is represented by the following formula:

$$(MN_1+MN_2)+HN$$

xi. Formula based on xxiii formula, representing a Construct on bracketing for left-branching approach.

Having said this, the rest of the Constructs is largely-self explained and argues vocabulary primitives will provide conceptualisation towards goal clarification. The table below identifies the current collection of Constructs for this research:

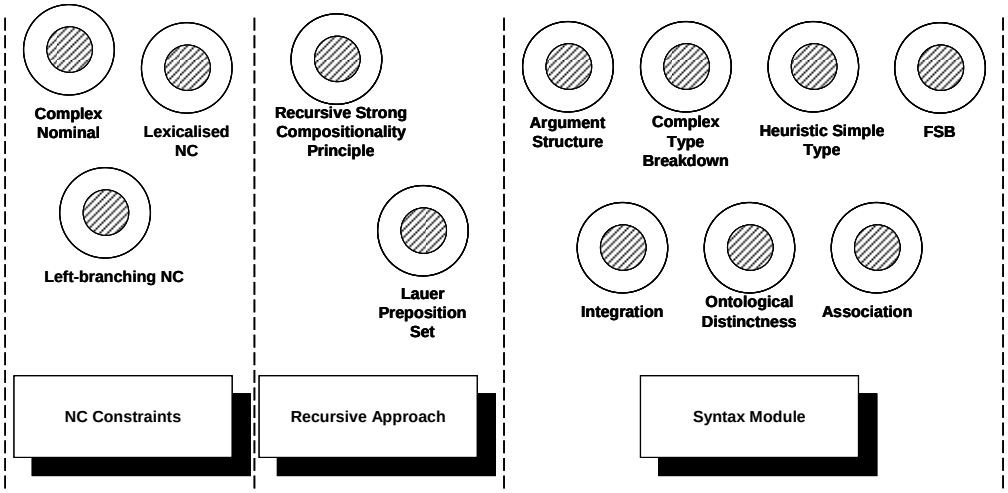
Construct	Description	Literature Review Section
Left-branching Noun Compound $(MN_1+MN_2)+HN$	NC representing left-branching instances that will herein be studied from a review-based perspective, converting the selection problem of right versus left association, into a left-branching analysis. For instance $(MN_1+MN_2)+HN$= "calcium ion exchange", will be broken into "exchange" of "ion of type calcium".	NC Constraints
Lexicalised Noun Compound	Non-compositional NC are part of a superordinate class of CNs, that have lost their direct relations to compositional values of the whole compound, for instance "guinea pig", "opera soap", "brain bird".	NC Constraints
Recursive Approach	Collection of interpreted pairs of NNC, in a recursive way expressing strong compositionality principles and heuristics to follow a constructivist approach (Pustejovsky, 1995).	Recursive Approach
Small-sized Preposition-based Set	Semantic cluster of implicit relations between noun constituents to tag NC interpretation using Lauer's set (1995a) to provide paraphrasing and support semantic transformations	Recursive Approach

	enabling prepositional ways of paraphrasing (henceforth PWOP).	
FSB	Boundary construals will work out "at the moment of use" meanings for any given noun via dictionary senses considered FSBs. A cognitive constrain argues the set of all FSBs associated to a given noun does not entail hyperonymic readings.	Syntax Module
Argument structure	Collection of syntax arguments and lexical hierarchies of a noun to convey representation of syntactic parameters into semantic realisations enabling simple, unified, or complex types.	Syntax Module
Complex Type Breakdown	Heuristic operation to analyse complex clusters of dotted types to break them down into simple types. Notions of the GLT enable clustering of multiple different senses in a structure called Lexical Conceptual Paradigm (LCP) for dotted or complex types, allowing for unification of a proposition and a simple type.	Syntax Module
Heuristic Simple Type	Heuristics operation to unify senses or FSBs -collection of simple types- from broken down simple types into experimental simple types.	Syntax Module
Ontological distinctness	Vertical dimension in a conceptual space of FSBs to quantify properties of distinctness of senses in association providing ODOF performance measures.	Syntax Module
Integration	Horizontal dimension in a conceptual space of FSBs to quantify properties of integration of senses in association providing IOF performance measures.	Syntax Module
Association	Operation to unify heuristic simple types –lexical hierarchies- representing the degree of association in terms of ODOF and IOF measures accounting for collaboration of senses of a NC.	Syntax Module

xii. Table containing Constructs to meet 1st research objective of the diagram vi defining conceptualisation in NC domains to deliver a 1st artefact.

The table above has provided elements for conceptualisation to clarify goals based on thoroughly review-based findings. The Construct table constitutes the first derivable according to diagram vi and enables Model semantics preparing immediate organisation of the main vocabulary relations.

The below diagram graphically represents the Constructs as elements of primitive semantics:



xiii. Figure representing the first artefact containing primitive Constructs.

4.1.3. Models

This section defines the major interrelations between Constructs from the last section. According to methodological chart vi, above Construct relationships have just described the problem statements prior to any data processing.

However Models tend to represent just descriptive associations between Constructs, some Models can be, in turn, the result of initial transformations (March, 1995). Due to this fact, some Models below will depict transformational work and data rearrangements throughout the solution process.

The Models below have been divided into 1)Models of Problem Statements and 2)Models of Solution Statements.

The latter Models envisage operational transformations –the soft part of the Dynamic Construal of Meaning framework-, while the former ones appealed strictly conceptualised vocabulary–the hard part of the Dynamic Construal of Meaning framework.

The table below describes the main interrelations between Constructs surfaced during the Awareness phase:

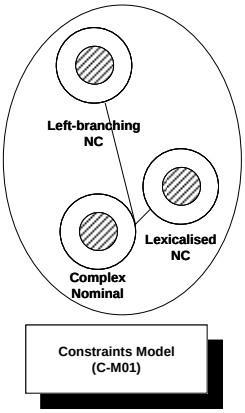
Model-ID	Model	Type	Description
C-M01	Constraints Model	Problem Statement	This model review-based model defines constrained conceptual combinations and special NC classes to encourage a system of operational constraints, resulting in leaving out lexicalised NCs, and proceeding to select left-branching NC over debate on left versus right selection bracketing.
SP-M02	Syntactic Parameters Model	Problem Statement	This model realises argument Arg1, Arg2, Arg3 levels of syntactic abstraction retrieve type as well as hierarchical information per FSB for each noun constituent, encompassing the hard part of the cognitive framework (Croft, 2004; Cruse, 2001). Dotted types are broken down into simple types -FSBs – being retrieved from the knowledge base.
RC-M03	Recursive Compositionality Model	Solution Statement	This model arranges elements of the syntax into a recursive template and builds lexical hierarchies per pair of nouns P(Arg1, Arg2)
PS-M04	Prepositional Semantics Model	Solution Statement	This model transforms elements of the syntax –orthogonal type inheritance and formal roles- via semantic rules - preposition-based semantics- and typing operations – heuristic simple type- into NC paraphrasing, accounting for the soft part of the cognitive model (Croft, 2004; Cruse, 2001).
DOA-M05	Degree of Association Model	Solution Statement	This model chains parameters of integration (IOF) and ontological distinctness (ODOF) across a conceptual space, to characterise degree of association between FSBs accounting for ambiguity in noun compounding (Croft, 2004).

xiv. Table containing Models according to the diagram vi defining interrelations between Constructs to deliver the 2nd Artefact.

The Model table above represents the 2nd Artefact. It has provided for operational behaviours and interrelations as identified in the Construct collaboration, which will embody a research situation to describe “how things are” (March, 1995, p. 256). Essentially, the above Models will help hint heuristics to address the internal Semantics of the Artefact D. The details of the behaviours have been explained as follows:

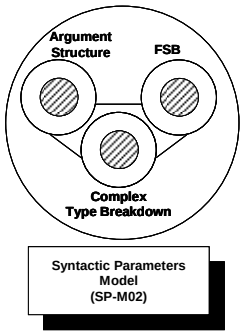
- **Constraints Model (C-M01):** This Model enables constraint systems to reinforce meaningful NC structures. Contextual constraints are not taken into account, namely immediate linguistic environment, type of discourse, physical context, stored knowledge, etc. (Croft, 2004; Cruse, 2001). Context is not relevant to this dissertation which will study contextual effects at a review-based only. The main structural

aspects will be constrained as non-lexicalised left-branching NCs.



xv. Figure representing the Constraint Model (C-M01).

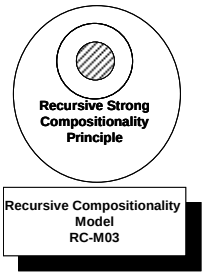
⌦**Syntactic Parameters Model (SP-M02):** This model represents the hard part of the dynamic construal of meaning to realise fixed elements –syntactic- of the Argument structure, as lexical hierarchies. The Model transforms the Argument structure into procedural input made up of FSBs and simple types from a knowledge base.



xvi. Figure representing the Syntactic Parametric Model (C-M02).

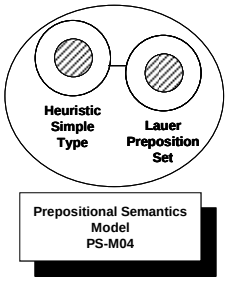
⌦ **Recursive Compositionality Model (RC-M03):** This Model realises a recursive mechanism to break down complex interpretations. It handles the Argument parameters to entail SRs as well as paraphrasing for each pair of nouns.

It fulfils iterative interaction of the syntactic elements to grapple with concepts of strong compositionality –recursive notions that ensure a roughly constant number of stored senses will result in all generated "at the moment of use" paraphrasing (Pustejovsky, 1995).



xvii. Figure representing the Recursive Compositionality Model (C-M03).

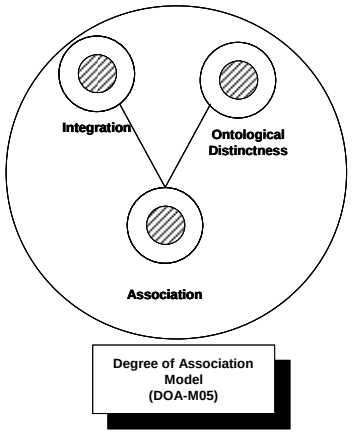
⌦ **Prepositional Semantics Model (PS-M04):** This model processes transformations of prepositional paraphrasing. Basically it analyses syntax, semantic rules and simple typing to account for the semantics of the soft part of the dynamic construal of meaning framework (Croft, 2004; Cruse, 2001). Essentially, the Model connects chains of intermediate processing to convey semantic output. Procedurally so to speak, the Model starts mechanisms of interpretation to raise semantic awareness in terms of prepositions.



xviii. Figure representing the Prepositional Semantics Model (PS-M04).

⌦ **Degree of Association Model (DOA-M05):** This Model processes noun meanings and prepositional paraphrasing to

explain the integration/distinctness parameters. It acquires previous hierarchical output to lead ontological distinctness (ODOF) and prepositional output to characterise integration (IOF). Both indexes of association will provide for criteria to classify NC ambiguity in order to lay down the performance measures of the Proposal.



xix. Figure representing the Degree of Association Model (DOA-M06).

This section developed the Models of this dissertation as influenced by the Constructs in order to conceptualise/represent a situation research. The above Models aimed at outlining the performance measures of the Proposal to elaborate on an initial solution, which will evolve the clarification goals into problem-solving procedures in the next section.

4.1.4. The Proposal

This section will elaborate on a Proposal to inform the detailed interplay of the initial research situation. According to diagram vi, the Proposal will meet the 2nd Objective. The Proposal will document comprehensive reviews and ideas on interaction between Constructs and Models to underlie the performance measures towards the Evaluation phase. The points of the present Proposal will reflect two types of elements: 1)the most influential factors of solution statements and 2) the

most salient performance measures informing the present research situation. The proposal is as follows:

⌦ **Influential Factors about the Constraint Model:** The constraint systems will not be thoroughly implemented in this research, but approach from a review-based point of view. Hence a review-based left-branching approach will be enabled to deal with context awareness. Contextual elements are not part of the present computational implementation of the system of constraints.

⌦ **1st Performance Measure- Constraint Model:** The contextual system of constraints will help restate the present problem research as a generative problem to include all prepositional paraphrasing. This dissertation's generative viewpoint does not conflict with the research aim's multiple "at the moment of use" meanings. These successful criteria of the built Artefacts will be based on all generated preposition output instead.

⌦ **Influential Factors about the Syntactic Parameters Model:** SEL senses or FSBs as queried from an electronic dictionary will be considered the major syntactic input of the system. In the Dynamic Construal of Meaning framework, FSBs will supply for the hard part of the paradigm. The knowledge base queries will provide undistinguishable homonymy/polysemy input at the level of broad polysemy. The electronic lexical hierarchies will provide heuristic types in terms of type inheritance elements.

⌦ **Performance measure in the Syntactic Parameters Model:** No performance measures were indentified.

⌦ **Influential Factors about the Recursive Compositionality Model:** The present recursive strategy will break down a NNNC structure into two pairs of NNC structures, (MN_1+MN_2) and (MN_2+HN) using formula xi. This approach will enable a strong compositionality point of view to support computationally tractability, via mechanisms of interpretation "at the moment of use" (Pustejovsky, 1995). Heuristics will enable the simple typing.

⌦ **2nd Performance Measure- Recursive Compositionality Model:** The approach to breaking down complex structures into two-noun structures will allow settling the corresponding criteria for testing NNC in the symbolic paradigms.

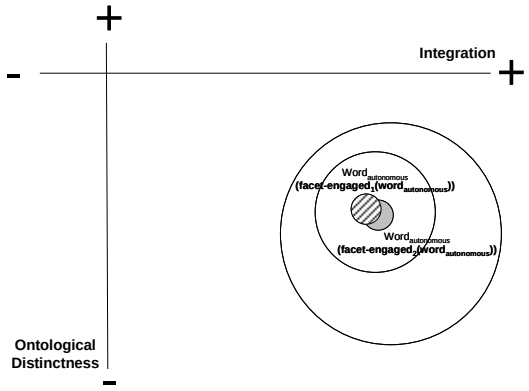
⌦ **Influential Factors about the Prepositional Semantics Model:** The pivotal Methods of semantics will be provided by paraphrasing mechanisms –internal rules, sets of prepositions and simple type operations- to convey the work of the strong compositionality compounding principle.

⌦ **3rd Performance Measure- Prepositional Semantics Model:** Preposition output will deliver criteria allowing the identification of either semantically successful or semantically ill-formed interpretations. This Model will enable the storage of quantitative interpretation as well as lexical hierarchies on the grounds of non-null paraphrasing.

⌦ **Influential Factors about the Degree of Association Model:** This Model will deliver the explanation of the modes of association between senses of noun constituents in a two-dimension conceptual space. Association will be enabled via quantitative paraphrasing –integration- and lexical hierarchies –ontological distinctness- to account for NC ambiguity.

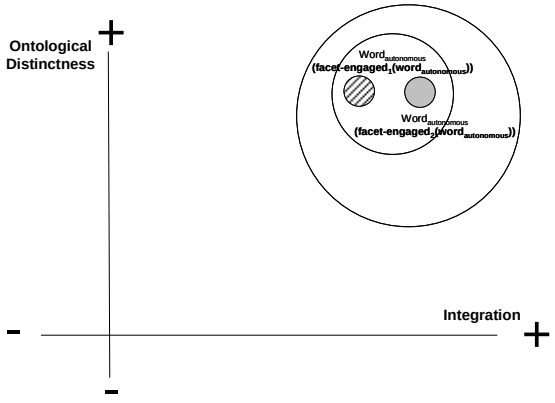
⌦ **4th Performance Measure- Degree of Association Model:** This Model will provide the means to asses association and summarises template elements. A cartesian plane will represent each of four regions: Scenario I, Scenario II, Scenario III and Scenario IV. It will represent integration/ontological distinctness measures. Each region aims to provide ranking of ambiguity classification. Integration will be represented by a integer p, i.e. IOF=p, whereas ontological distinctness is represented by a p-tuple of integers lh_k, i.e. ODOF=(lh_1,lh_2, …, lh_p). The integer p represents the number of different prepositions in the cluster associated to the NC. Each element lh_k of the tuple represents the number of different lexical hierarchies associated to preposition k in the cluster. NC ambiguity in Scenario I is represented by the measure (IOF=1, ODOF(1)), which is called an autonomously exclusive element of the lexicon (henceforth AXEL) NC. Scenario II is represented by (IOF=2, ODOF(1,1)), which is called a monosemous NC. Likewise Scenario III is represented by as (IOF=m, ODOF(1,1,…, 1_m)), which is called a polysemic NC. Finally, Scenario IV is represented by (IOF=t, ODOF(r_1,r_2,…, r_t)), a least one r_i>1, which is called an extremely polysemic NC.

The graphs below show the four main regions along with the corresponding computational templates activated by Model DOA-M05:



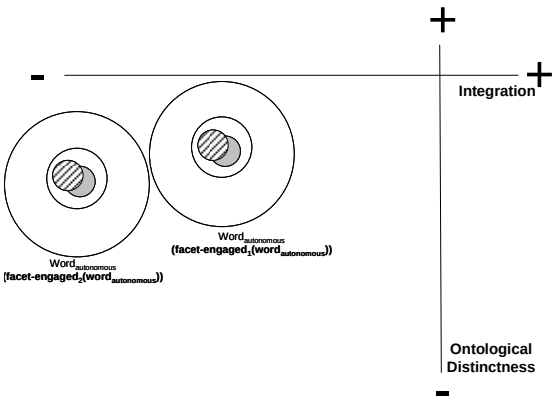
Words in Combination	Autonomous Word	Construal	Engaging Element	Portion of Meaning Engaged	Portion of Meaning Left Out	IOF	ODOF
MN_1+MN_2	MN_2	boundary	MN_1	sense-engaged$_1$(MN_2)	sense-left-out$_1$(MN_2)		
MN_2+HN	HN	boundary	MN_2	sense-engaged$_2$(HN)	sense-left-out$_2$(HN)		
(MN_1+MN_2)+HN	HN	$PWOP_1$ - $PWOP_2$	MN_1+MN_2	sense-engaged$_{1+2}$(HN)		+	-

xx. Chart and template representing Scenario I with values (+,-)of degree of association for FSB, to characterise AXEL NCs.



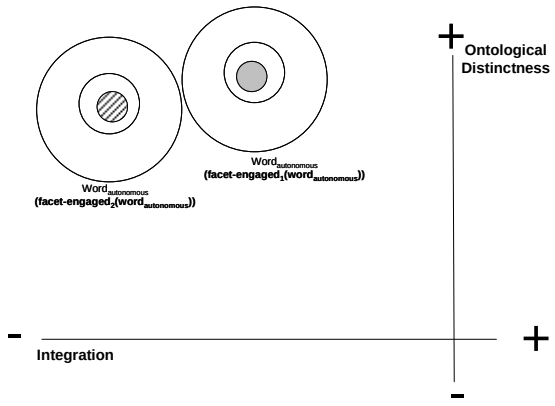
Words in Combination	Autonomous Word	Construal	Engaging Element	Portion of Meaning Engaged	Portion of Meaning Left Out	IOF	ODOF
MN_1+MN_2	MN_2	Boundary	MN_1	sense-engaged$_1$(MN_2)	sense-left-out$_1$(MN_2)		
MN_2+HN	HN	boundary	MN_2	sense-engaged$_2$(HN)	sense-left-out$_2$(HN)		
(MN_1+MN_2)+HN	HN	$PWOP_1$ - $PWOP_2$	MN_1+MN_2	sense-engaged$_{1+2}$(HN)		+	+

xxi. Chart and template representing Scenario II with values (+,+)of degree of association for FSB, to characterise monosemous NCs.



Words in Combination	Autonomous Word	Construal	Engaging Element	Portion of Meaning Engaged	Portion of Meaning Left Out	IOF	OD OF
MN_1+MN_2	MN_2	boundary	MN_1	sense-engaged$_1$(MN_2)	sense-left-out$_1$(MN_2)		
MN_2+HN	HN	boundary	MN_2	sense-engaged$_2$(HN)	sense-left-out$_2$(HN)		
(MN_1+MN_2)+HN	HN	PWOP$_1$ - PWOP$_2$	MN_1+MN_2	sense-engaged$_{1+2}$(HN)		-	-

xxii. Chart and template representing Scenario III with values (-,-)of degree of association for FSB, to characterise polysemic NCs.



Words in Combination	Autonomous Word	Construal	Engaging Element	Portion of Meaning Engaged	Portion of Meaning Left Out	IOF	OD OF
MN_1+MN_2	MN_2	boundary	MN_1	sense-engaged$_1$(MN_2)	sense-left-out$_1$(MN_2)		
MN_2+HN	HN	boundary	MN_2	sense-engaged$_2$(HN)	sense-left-out$_2$(HN)		
(MN_1+MN_2)+HN	HN	PWOP$_1$ - PWOP$_2$	MN_1+MN_2	sense-engaged$_{1+2}$(HN)		-	+

xxiii. Chart and template representing Scenario IV with values (-,+)of degree of association for FSB, to characterise extremely polysemic NCs.

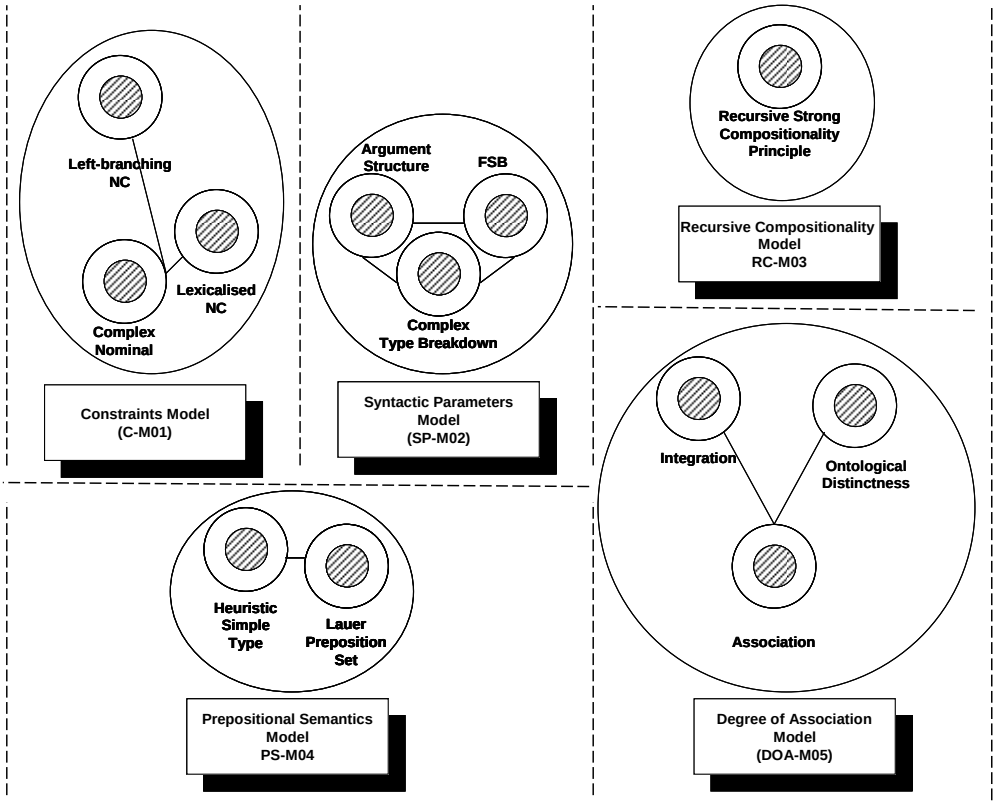
The Models of this section will constitute the ordered elements of the Design to build a procedural solution. Following the Proposal, the next section will deal with the Design of this dissertation.

4.2. THE TENTATIVE DESIGN

4.2.1. Initial Settings

The present section will formulate the Design process as a Dasgupta's AI problem (1992) to parallel a course of action for changing an initial state of affairs into a desired one (Dasgupta, 1992; Blessing, 2009).

Ultimately the AI characterisation will help evolve an initial situation into a goal situation. The present initial situation is described below in terms of Models from the last section:



xxiv. Figure representing Models describing an initial research situation S_0.

⌦ **Initial Situation S_0**: The initial state S_0 is described by a set of review-based constraints on NNNCs (C-M01), with the Argument information and syntactic parameters readily attached (SP-M02). At the initial state, NCs lack the algorithms and structures to provide NNC paraphrasing recursively (RC-M03 and PS-M04). Consequently at the initial state, the degree of association for a NNNC is largely unaccounted for, hence leading to a lack of qualitative ranking for ambiguity characterisation (DOA-M05).

⌦ **Goal Situation S_g**: The goal state S_g is reached when NCs in the constraint system (C-M01) along with the syntax elements (SP-M02) will be used to generate all meaningful interpretations. The solution provides multiple pairs of NNC prepositional paraphrasing $PWOP_1$ and $PWOP_2$ (RC-M03 and PS-M04) to cope with the association index (DOA-M05) towards ranking ambiguous contents of NNNCs.

In the next section the AI paradigm representation will be described in terms of a set of Operators (henceforth terminology for Operator with first letter in capitals) (Dasgupta, 1992) or Methods (March, 1995) in progressive transformation, until the desired S_g is reached, which will deliver the Tentative Design D.

4.2.2. Methods of the Design D

This section will organise a procedural set of steps to achieve the desired situation S_g via Operators to account for the internal structure of the Design D.

The following convention in this dissertation will help classify Operators as follows: 1)invariable Operator, 2)input-processing Operator and 3)transformational Operator.

An invariable Operator causes no changes at all in the internal structure of the input, due to review-based scope characterisation. An input-processing Operator formats data structures to deploy useful input to Methods in the Design. Finally, a transformational Operator translates contents of a Model into a new Model in the course of actions to reach a specific situation.

The table below describes functionality of Operators involved, as follows:

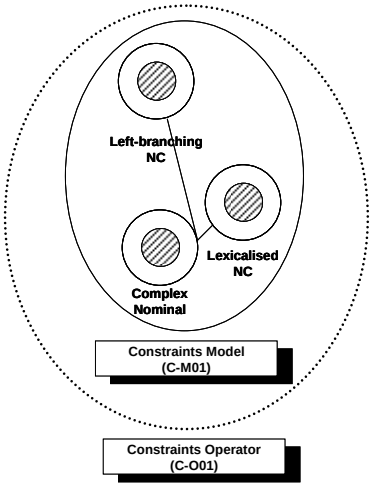
Operator-ID	Operator	Type	Description
C-O01	Constraints Operator	Invariable	This Operator retains operational constrains for the system. The Operator results in no new data processing, as it behaves as an invariable Method that maps a value x=Model onto itself x=Model.
S-O02	Syntax Operator	Input Processing	This Operator acquires lexical information and formats argument elements to deploy meaningful output to be taken as an input by other processes. This method's functionality is minimally productive.
PWOP-O03	Prepositional Ways of Paraphrasing Model	Input Processing	This Operator pieces together syntax information of prepositional paraphrasing and resulting types to format semantic input of Models and Methods.
P-O04	Paraphrasing Operator	Transformational	This Operator transforms syntactic input into paraphrasing semantics fulfilling a strong compositionality principle to deliver intensely hands-on processing
A-O05	Association Operator	Transformational	This Operator process paraphrasing and lexical hierarchies to conflate integration (IOF) and ontological distinctness (ODOF) indexes into a unified reading of a conceptual space, in order to characterise association accounting for ambiguity in noun compounding (Croft, 2004).

xxv. Table containing Operators according to the diagram vi defining transformations of Models to deliver the 3rd Artefact or Tentative Design.

The following paragraphs will explain the internal organisation of each Operator in detail to prepare the delivery of the Design D. The functionality of each Operator as follows:

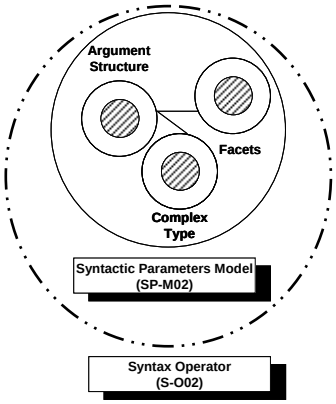
- **Constraints Operator (C-O01):** This Operator will deal with the review-based constraints in the system by deactivating irrelevant constraints, namely contextual

constraints, etc., and activating left-branching constraints, as processed by Model C-M01.



xxvi. Figure representing the Constraints Operator (C-O01)

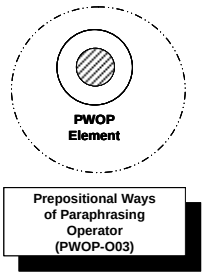
⌦ **Syntax Operator (S-O02):** This Operator will structure retrieved parameters from the knowledge base by breaking them down into primitive components. The parameters will be formatted as input required by other Methods in the Design.



xxvii. Figure representing the Syntax Operator (S-O02)

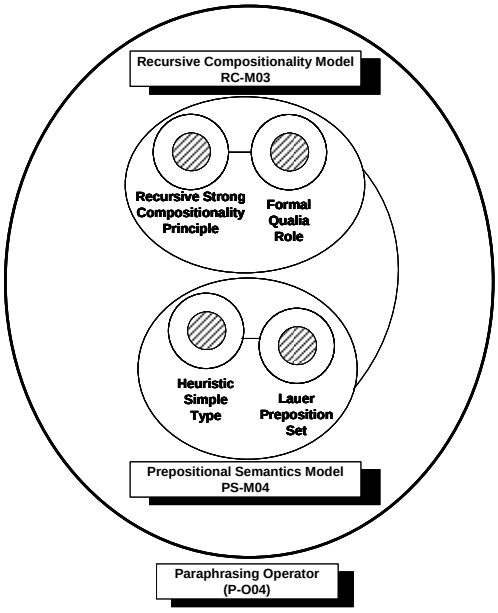
⌦ **Prepositional Ways of Paraphrasing Operator (PWOP-O03):** This Operator will format meaningful prepositional paraphrasing. Essentially the resulting “on-line” prepositions

will await processing of the syntactic mechanisms in order to be transformed into useful input for other Models.



xxviii. Figure representing the Prepositional Ways of Paraphrasing Operator (PWOP-O03).

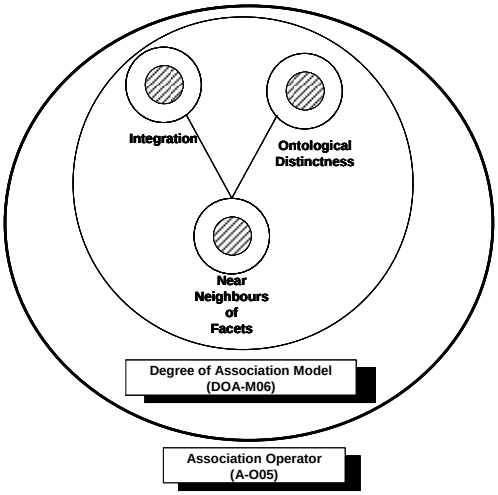
⌦ **Paraphrasing Operator (P-O04):** This Operator will transform NNCs into active elements of Semantics, by involving both prepositional paraphrasing and type inheritance Models.



xxix. Figure representing the Paraphrasing Operator (P-O04)

⌦ **Association Operator (A-O05):** This Operator will enable ambiguity ranking by weighing the meaningful input to deal with the degree of association between noun constituents. The method will translate the increased knowledge about the

acquired lexical information via mechanisms of association, which will basically account for ambiguity interpretation in a two-dimensional space.



xxx. Figure representing the Association Operator (A-O05)

This section organised the Models of this dissertation to deal with the lexical data structures, algorithms and semantic rules towards a collection of Operators. The next section will use this pre-design characterisation to collide Operators in a sequential fashion to reach the goal state S_g.

4.2.3. The Tentative Design D

The Methods from the last section will be used to build the Tentative Design D in order to constitute the internal collaboration of algorithms and data of the AI Paradigm (Dasgupta, 1992). The above Operators will be used to mainly organise the increased clarification of the findings about NCs towards an explanation of the internal environment of the Artefact. The sequential selection of Operators –the Tentative Design D- as follows:

⌦ **1st Step.- C-O01:** This step will acknowledge the general constraints following the review-based findings, which has the

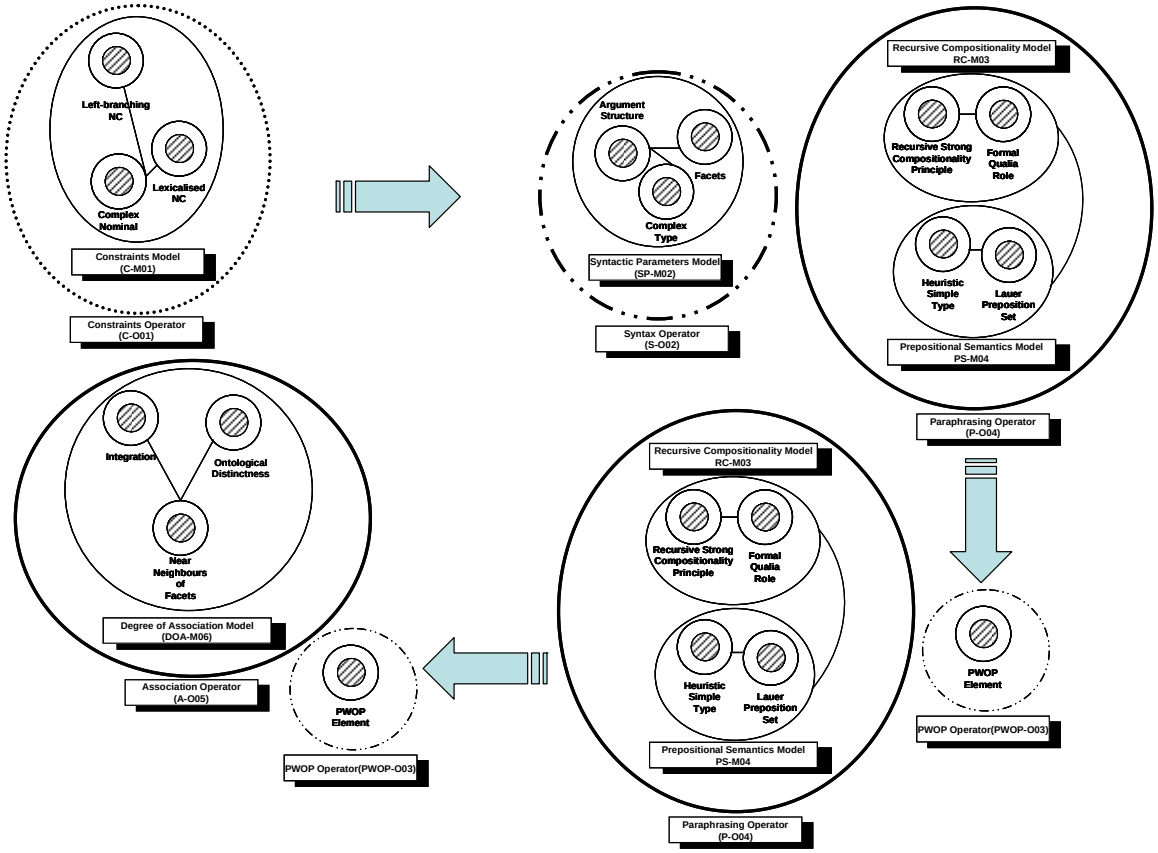
effect to process no change in the internal logic of the constraining Models. This phase will emphasise the awareness over bracketing limitations for the present research.

⌦ **2nd Step.- S-O02 followed by P-O03:** This step will fulfil input construction and semantic processing in a sequential fashion. The present Design will intend to set up the syntactic parameters to provide input for Operator P-O03 to deal with semantic interpretation. The internal data connections and algorithms of Operator P-O03 will enable type operations over the simple types to increase the semantics of the framework. Likewise, all heuristic prepositions will provide the meaningful grounding for the increased semantics. The Models that hold the recursive templates will guarantee "at the moment of use" meanings to include all meaningful interpretations via prepositional semantics.

⌦ **3rd Step.- PWOP-O05 followed by P-O03:** This step will fulfil the prepositional input construction and semantics processing in a sequential fashion. The functionality of the earlier Model PWOP-M05 will be translated into parameters to provide format input. Similarly, Operator P-O03 will therefore receive the prepositional parameters to deal with semantic interpretation. Additionally, recursivity mechanisms will enable the second iteration to involve the same internal data connections and algorithms from the Step 2nd.

⌦ **4th Step.- PWOP-O05 followed by A-O04:** This step will support the prepositional input construction and principles to quantitatively classify the concepts of integration and ontological distinctness, in a sequential fashion. The Operators will help build the indexes to prepare the object allocation into regions depending on how polysemic each interpretation might be.

As stated, The above 4th step will reach the goal state S_g. Overall, this set of ordered steps constituted the Design, which has met the 3rd Objective to provide a solution. The graph below shows the Design D:



xxxi. Figure describing the Design D as a set of steps resulting in one solution of the solution space.

The next section will present a summary to reflect on the influence of the acquisition of the increased knowledge towards clarification of goals, which has resulted in a Tentative Design D.

4.2.4. Chapter Summary

This chapter dealt with the creation of a Tentative Design D. The present Artefact-intensive approach complied with an AI Paradigm characterisation aiming at expediting the procedural Model interactions and transformations of this methodology (Dasgupta, 1992).

The present research problem has conducted a search through the solution space until state goal S_g, was reached, therefore solving a Design problem (Dasgupta, 1992). The algorithms and data structures of the Design were packed to show the solution statements evolving the internal logic of the collection of Operators. Such a collection conducted transformations to involve NC interpretation, preposition paraphrasing, recursive compositionality, and association operations.

The Tentative Design D as part of the methodology from figure vi, has mediated between a research Proposal and a practical implementation. As a result of this, an approach to developing the Artefact A will unfold towards Design assessment in the next chapter.

5. IMPLEMENTATION

5.1. THE DEVELOPMENT STAGE

5.1.1. Introduction

This chapter will deliver a practical implementation to develop a Design instantiation according to figure vi. The computational implementation will process programming techniques and interfaces with the knowledge base. The present implementation will be based on the earlier findings from the Literature Review to reveal the influence of the Symbolic Paradigm on the acquisition of lexico-semantic interpretation (Lapata, 2000).

The computational techniques involved in the production of the Artefact A will determine the nature of the internal algorithms packed as part of the whole solution. As a result, the Artefact A will involve manual interfaces with WordNet to fulfil semi-automatic retrieval of the syntactic parameters.

During development and owing to the nature of Operators, heuristic paraphrasing will be used over training sets of the Evaluation phase, ahead of work for testing in Chapter 6. Also at this point, the designer's criteria will attempt to learn the internal structures of NCs in order to find semantic rules for paraphrasing. The details of the rule's acquisition will be included in Appendix D.

Some notions of development language will be used to guide the artefact construction via UML-Case diagrams to communicate the requirements of the Artefact A. As this work is not interested in the novelty of techniques to build the Artefact A, the details of development will be less resourced and fundamentally transparent for the reader. The novelty will be centred on the Design D, instead (Vaishnavi, 2004).

The next section will start the discussion over data architecture issues of the Artefact A, to deal with the knowledge base and its impact on the nature of the implementation.

5.1.2. WordNet as a Knowledge Base

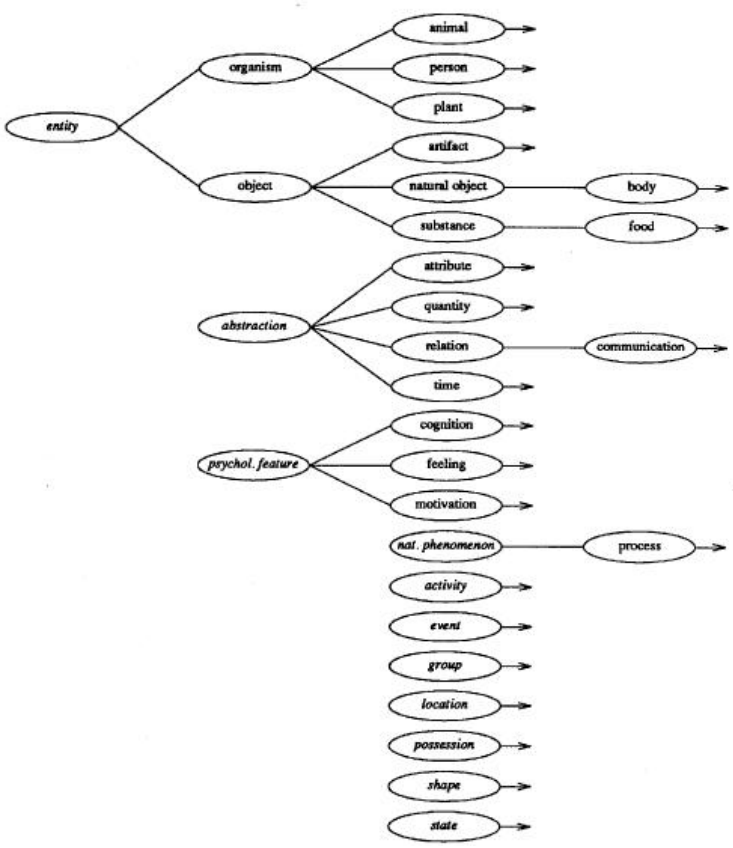
Lapata (2000) has already documented a widely used approach to semantic interpretation of NCs called the Symbolic Paradigm. The lexico-semantic component in this Paradigm is called the "knowledge base", which basically works as semantic proxy to acquire parameters on NCs, at a later stage to be used in interpretation. In this dissertation, WordNet will be the knowledge lexical database to cover functional requirements of the Symbolic Paradigm. The used version 2.1 of the WordNet software as of writing is available on the University of Princeton's website (Princeton University, 2010).

WordNet is widely-used as a semantic resource in various NLP tasks with more than 20 years of active research (Fellbaum, 1998). The WordNet database has enabled an alternative approach to the semantic analysis via lexical knowledge of the English language, influencing the creation of lexical projects to encourage WordNet products in other languages, especially from the European Community (Vossen, 1998).

A salient semantic characteristic implemented in WordNet is the so-called relational semantic approach, in which structures for nouns are represented by associations between semantically connected words via several lexico-semantic relationships, namely hyponymy, hyperonymy, meronymy, and antonymy (Fellbaum, 2007).

WordNet hypernym network for nouns will offer basic functionality in terms of lexical hierarchies, which can be processed by GLT typing operations to analyse relevant syntactic information. Thus WordNet hierarchical elements will enable hypernym operations over types to heuristically define simple types assisting in

formulating semantic rules. Lexical hierarchies are largely self-explained and are based on the Classical Theory of concepts. This work does not discuss complexities about understanding inheritance in WordNet, instead it assumes its general organisation. In-depth reading is thereby referred to the original source (Fellbaum, 1998). Excerpts of the hierarchical organisation in WordNet are shown below:



xxxii. Figure of a diagrammatic representation of lexical hierarchies in WordNet, taken from (Fellbaum, 1998)

Hierarchies will be queried under the WordNet lexical model to obtain elements of the type system realising simple types of the GLT, from a heuristic point of view. Each sense associated to a noun will be considered a simple type in terms of the Argument structure. WordNet lexical structures will therefore allow collecting syntactic information of FSBs. Even though some nouns might not have unique identifiers, their hierarchical information will be broken down in free simple types representing separate lexical hierarchies.

For instance, the noun book in WordNet contains non-unique lexical hierarchies for sense 6, as follows:

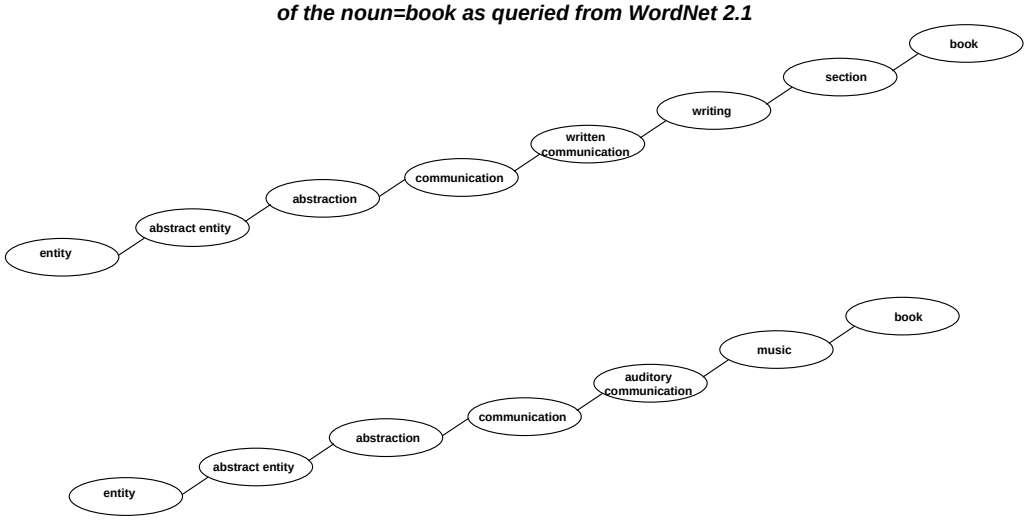
Sense 6
book -- (a major division of a long written composition; "the book of Isaiah")
=> section, subdivision -- (a self-contained part of a larger composition (written or musical); "he always turns first to the business section"; "the
=> writing, written material, piece of writing -- (the work of a writer; anything expressed in letters of the alphabet (especially when considere
is excellent"; "that editorial was a fine piece of writing")
=> written communication, written language -- (communication by means of written symbols)
=> communication -- (something that is communicated by or to or between people or groups)
=> abstraction -- (a general concept formed by extracting common features from specific examples)
=> abstract entity -- (an entity that exists only abstractly)
=> entity -- (that which is perceived or known or inferred to have its own distinct existence (living or nonliving))
=> music -- (an artistic form of auditory communication incorporating instrumental or vocal tones in a structured and continuous manner)
=> auditory communication -- (communication that relies on hearing)
=> communication -- (something that is communicated by or to or between people or groups)
=> abstraction -- (a general concept formed by extracting common features from specific examples)
=> abstract entity -- (an entity that exists only abstractly)
=> entity -- (that which is perceived or known or inferred to have its own distinct existence (living or nonliving))

xxxiii. Figure showing a screen from WordNet 2.1 containing lexical hierarchies associated to sense 6 of the noun=book.

This dissertation will therefore assume that the above lexical hierarchies can lead to two separate hierarchical forms, as follows:

Lexical Hierarchy	Noun	Sense or Gloss
entity/abstract entity/abstraction/ communication/written communication/writing/section/boo k	book	A major division of a long written composition; "the book of Isaiah"
entity/ abstract entity/abstraction/ communication/auditory communication/music/book	book	A major division of a long written composition; "the book of Isaiah"

xxxiv. Table representing separate lexical hierarchies considered to be simple types from the GLT, derived from sense 6 of the noun=book as queried from WordNet 2.1



xxxv. Figure representing separate lexical hierarchies considered to be simple types from the GLT, derived from sense 6 of the noun=book as queried from WordNet 2.1

The above structure indicates how WordNet senses will provide for FSBs to supply syntactic types and lexical information to format meaningful input for some other Operators.

The present implementation will consider the lexical hierarchies as the result of an abstract transformation T, which returns the simple type associated to a FSB. For instance, one of above senses for noun=”book” following the application of T results in:

T(book$_{\text{sense-6}}$**)=entity/abstract entity/abstraction/communication/written communication/writing/section/book**

xxxvi. Formula representing type transformation T for sense 6 of the noun=book as queried from WordNet 2.1

This characterisation of syntactic types from WordNet revealed close-knit binding between tools and Operators, pressing for lexical hierarchies to influence a top-down development of the Artefact A (March, 1995). Parameter collaboration will be explained in the next section in more detail resulting in the first steps towards development of the Artefact A.

5.1.3. Functional Requirements

This dissertation considers programming techniques to be tangential in assisting comprehensive understanding of the Artefact A, in terms of an integrated view of software development alone. Instead, it is more interested in the implementation itself, rather than experiencing the process of development (Vaishnavi, 2004).

However in order to assist the creation of the Artefact A, some initial statements of the requirements will be made to provide some functional specification. To this end, the requirements will be translated from Chapter 4 at the end of the Tentative Design D section. The next set of initial statements of requirements specifies the functional needs as follows:

⌦ **1st Statement of Requirements:** The Artefact A processes NNNCs provided as left-branching structures, like those of formula xi.

⌦ **2nd Statement of Requirements:** The Artefact A collects syntactic information from the knowledge base WordNet for each noun constituent in the NC input.

⌦ **3rd Statement of Requirements:** The Artefact A applies recursively semantic rules to deliver prepositional paraphrasing, based on syntactic information provided by syntactically conflated FSBs –heuristic simple types- from acquisition of the 2nd statement of requirements.

⌦ **4th Statement of Requirements:** The Artefact A formats prepositional output from the 3rd statement of requirements.

⌦ **5th Statement of Requirements:** The Artefact A classifies resulting prepositional paraphrasing to estimate integration (IOF) and ontological distinctness (ODOF) indexes to inform how polysemic each NC interpretation is.

The requirement model above has described the functional behaviours of the Artefact A in order to specify a set of requirements. As a result, a system will be developed at a basic level following a graphical representation of software specification. Some software modelling elements will be outlined via Use-Case diagrams.

5.1.4. Use-Case Model for the Artefact A

The following Use-Case view will be able to conduct subsequent development of the Artefact A. In order to develop a system to implement the Artefact A, some actors and Use-Cases are needed. Essentially, actors represent users that interact with the system, whereas Use-Cases describe what actors can functionally do with the system (Priestley, 2000).

This dissertation has indentified two major actors interacting between the systems and data architectures. The main user is the NC user or NC administrator. A second user is the knowledge base WordNet. Development includes a number of Use-Cases to establish functional drives throughout software building processes, as follows:

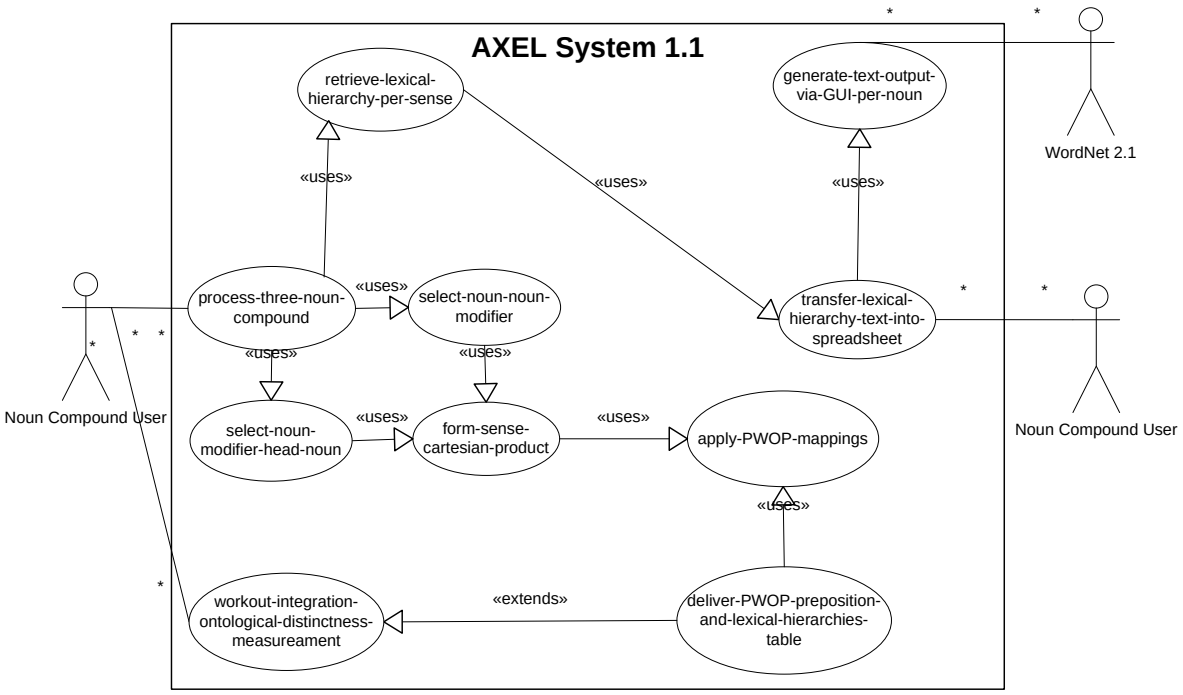
The 1st Statement of Requirements results in a Use Case dealing with NNNCs constraints securing left-branching structures. The target will be automatically fulfilled by the Use-Case “process-three-noun-compound”.

The 2nd Statement of Requirements is fulfilled by the Use-Case “retrieve-lexical-hierarchy-per-sense”, which controls syntactic querying to build meaningful Argument input. This Use-Case will automatically collect information from knowledge base sources. Such sources will be semi-automatically queried by the WordNet User –Use-Case “generate-text-output-via-GUI-per-noun”. However such information sources from WordNet will be manually transferred into meaningful data structures by the NC User, relaying on Use-Case “transfer-lexical-hierarchy-text-into-spreadsheet”. The second half of this Use-Case to deal with syntactic acquisition is to be manually implemented, due to time constraints. Hence the approach to interfacing will be review-based.

The 3rd Statement of Requirements is fulfilled by a processing-intensive Use-Case called “apply-PWOP-mappings”. This latter Use-Case applies automatically recursive semantics to deliver prepositional paraphrasing supported by data-intensive Use-Cases “select-Noun-Modifier-Noun-Modifier”, “select-Noun-Modifier-Head-Noun”, and “form-sense-cartesian-product”. This latter Use-Case is responsible for producing conflated senses. Use-Case “deliver-PWOP-preposition-and-lexical-hierarchies-table” will structure some auxiliary tables in order to format meaningful paraphrasing to manage the syntactic PWOP output of the system.

The 5th Statement of Requirements is realised via the PWOP output of the system from former Use-Case "deliver-PWOP-preposition-and-lexical-hierarchies-table". Essentially it seeks to find out if any successful criteria were met. Upon meeting the successful criteria, the association measures will be automatically delivered by Use-Case "work-out-integration-ontological-distinctness-measurement".

The figure below shows the graphical representation of the Use-Case diagram for an instantiation of the Artefact A, which will be called the "AXEL System":



xxxvii. Figure representing the Use-Case diagram for modelling internal organisation of a computing implementation for the present artefact A

The Use-Case specification above describes the functional requirements translated into the system's Use-Cases to inform the modelling operations of development. However, resulting Use-Case "apply-PWOP-mappings" must be detailed further in order to outline the internal organisation of the prepositional heuristics according to the Symbolic Paradigm. Such details will unfold sense-tagged mappings developed by Girju (2009a). Girju's work (2009a) will provide annotated tools to relate prepositions and type inheritance to ground semantic rules.

The next section describes how Girju's work (2009a) will interact with components of the AXEL System or the Artefact A to manage the instantiation of the internal engines of Use-Case "apply-PWOP-mappings".

5.2. SEMANTICALLY HAND-CODED SETS

5.2.1. Preposition Semantics for NC Interpretation

Semantics will motivate the present NNCs interpretation to account for NNNC paraphrasing through procedural steps of the AXEL System. The main objective of this section will be to introduce a meaningful mapping to bridge preposition paraphrasing.

Recently a study by Girju (2009a) has presented empirical observations on NC behaviours and their semantic role. Her published results on prepositions interpret Noun+Noun as well as Noun+Preposition+Noun structures in cross-linguistic research. As part of her findings, the study has built mappings between SRs and prepositions of the Lauer's set (1995a) to hint semantic correlation. Her relevant findings will ground the present semantics between simple types and preposition cataloguing.

Essentially, the Lauer's set has been a long-standing resource and highly benchmarked to test frameworks and experiments alike in order to fulfil prepositional semantic compatibility.

Regarding the set's semantics, the notions of semantic compatibility states that NNCs basically imply correlating compatibility with a particular preposition class P (Baldwin, 2009). For instance "baby chair" is compatible with the class FOR, as in "chair (FOR) baby". The Lauer's set is a collection of eight prepositions shown below:

Lauer's set of prepositions along with examples interpreted in context.

No.	Preposition	Examples
1	of	sea bottom (bottom *of* the sea)
2	for	leisure boat (boat *for* leisure)
3	with	spoon feeding (feeding *with* a spoon)
4	in	London house (house *in* London)
5	on	Saturday snowstorm (snowstorm *on* Saturday)
6	at	night flight (flight *at* night)
7	about	war story (story *about* war)
8	from	almond butter (butter *from* almonds)

xxxviii. Figure representing Lauer's preposition set, taken from (Girju, 2009a)

Regarding preposition resources, a recent Girju's article (2009a) has addressed syntactic and semantic properties of prepositions with respect to interpretation of NPs and NCs, which hinted close-knit correlation between preposition parameters and paraphrasing Semantics. Girju's study will be therefore used to provide the AXEL System rules on lexical hierarchies and relational mappings (2009a) by analysing simple types and lexical hierarchy interaction.

As part of this cross-linguistic study Girju's tables below -xxxix and xl- have been semantically tagged by experienced annotators to assist in the selection of prepositions from the Lauer's set. As annotators were not expected to agree on every NP, the classification category grew in membership, resulting in more than one category allocating multiple SRs. For instance, the SR Part-whole included the prepositions OF, IN, and WITH, which delivers multiple criteria for paraphrasing a NNC in the class.

Girju's analyses will help disambiguate the annotated clusters of prepositions by analysing an extra table -figure xli below-, which contains some 22 SRs. This table will provide the fundamental semantics to underpin the formulation of rules of prepositional interpretation in the AXEL system.

For example, in table xli the Girju's OF(Property) preposition can be obtained from pairing NNC= "lubricant viscosity", where MN_1=lubricant, MN_2=viscosity, corresponding to the SR Property of the table, i.e. SR 3 for MN_2=viscosity

OF(Property) MN_1=lubricant in table xli. The table below shows the first set of Girju's mappings:

Nr.	SRs	En.	Nr.	SRs	En.
1	POSSESSION	of, –	11	INSTRUMENT	
			12	LOCATION	of, in, on, –
2	KINSHIP				at
3	PROPERTY	of, for, in, –	13	PURPOSE	of, – for
4	AGENT	of, for, in, by, –	14	SOURCE	
			15	TOPIC	of, for, on, –
5	TEMPORAL	of, in, on, at, –			about
			16	MANNER	
			17	MEANS	by de, –
6	DEPICTION				
7	PART–WHOLE	of, in, with, –	18	EXPERIENCER	of,– in in
8	IS–A (HYPERNYMY)	of, – with	19	MEASURE	
			20	TYPE	–
9	CAUSE				
10	MAKE/ PRODUCE	of, for, – in, from	21	THEME	of, for, in, –
			22	BENEFICIARY	
			23	OTHER–SR	of, by

xxxix. Figure representing Girju's mapping between 22 semantic classification categories and the Lauer's set across the Europarl corpus, taken from (Girju, 2009a, p. 202)

Table xl shows the coding for a second semantically annotated corpus that corresponds to a semantic exercise in the Girju's analyses (2009a).

This dissertation will use tables xxxix, xl, and xli to settle prepositional rules by considering the global information in terms of prepositions. A detailed analysis will help build the heuristics for interpreting NNCs by using elements from the three tables altogether. The Girju's mappings (2009a) will drive the soft part of the Dynamic Construal of Meaning framework throughout the development of the AXEL system.

Nr.	SRs	En.
1	POSSESSION	of, –
2	KINSHIP	
3	PROPERTY	of, for, in, –
4	AGENT	of, for, in, by, –
5	TEMPORAL	of, in, on, at, –
6	DEPICTION–DEPICTED	of
7	PART–WHOLE	of, in, with, –
8	IS–A (HYPERNYMY)	of, – with
9	CAUSE	from, –
10	MAKE/ PRODUCE	of, for, in, from, –
11	INSTRUMENT	for, with
12	LOCATION	of, in, on, at, –
13	PURPOSE	of, – for
14	SOURCE	of, from
15	TOPIC	of, for, on, about, –
16	MANNER	
17	MEANS	of, by
18	EXPERIENCER	of, in, –
19	MEASURE	of
20	TYPE	
21	THEME	for, – of, in
22	BENEFICIARY	
23	OTHER–SR	of, by

xl. Figure representing Girju's mapping between 22 semantic classification categories and the Lauer's set across the CLUVI corpus, taken from (Girju, 2009a, p. 203)

Regarding the multiplicity of the prepositional approach in the Girju's analyses, the multiple representation of SRs for a prepositional cluster becomes problematic due to vagueness. This dissertation advocates for an empirical property of language that has been called the "multiple meanings" approach (Kidd, 2008).

Roughly, a "multiple meaning" theory ensures there are different meanings associated to a given element that ultimately form links between differentiated meanings into a prepositional network. For instance, preposition WITH unfolds multiple meanings interconnected in a network of prepositions for WITH(Accompaniment), WITH(Instrument), WITH(Modifier) and WITH(Manner) (Kidd, 2008). By doing so, this dissertation claims that indeterminacy due to

preposition encoding can be improved by resting upon a network of prepositions that will be able to handle its ambiguous semantics.

No.	Semantic relations	Default argument frame	Examples
1	POSSESSION	Arg_1 POSSESSES Arg_2	*family#2/Arg_1 estate#2/Arg_2*
2	KINSHIP	Arg_1 IS IN KINSHIP REL. WITH Arg_2	*the sister#1/Arg_2 of the boy#1/Arg_1*
3	PROPERTY	Arg_2 IS PROPERTY OF Arg_1	*lubricant#1/Arg_1 viscosity#1/Arg_2*
4	AGENT	Arg_1 IS AGENT OF Arg_2	*investigation#2/Arg_2 of the police#1/Arg_1*
5	TEMPORAL	Arg_1 IS TEMPORAL LOCATION OF Arg_2	*morning#1/Arg_1 news#3/Arg_2*
6	DEPICTION-DEPICTED	Arg_2 DEPICTS Arg_1	*a picture#1Arg_2 of my nice#1/Arg_1*
7	PART-WHOLE	Arg_2 IS PART OF (whole) Arg_1	*faces#1/Arg_2 of children#1/Arg_1*
8	HYPERNYMY (IS-A)	Arg_1 IS A Arg_2	*daisy#1/Arg_1 flower#1/Arg_2*
9	CAUSE	Arg_1 CAUSES Arg_2	*scream#1/Arg_2 of pain#1/Arg_1*
10	MAKE/PRODUCE	Arg_1 PRODUCES Arg_2	*chocolate#2/Arg_2 factory#1/Arg_1*
11	INSTRUMENT	Arg_1 IS INSTRUMENT OF Arg_2	*laser#1/Arg_1 treatment#1/Arg_2*
12	LOCATION	Arg_2 IS LOCATED IN Arg_1	*castle#1/Arg_2 in the desert#1/Arg_1*
13	PURPOSE	Arg_1 IS PURPOSE OF Arg_2	*cough#1/Arg_1 syrup#1/Arg_2*
14	SOURCE	Arg_1 IS SOURCE OF Arg_2	*grapefruit#2/Arg_1 oil#3/Arg_2*
15	TOPIC	Arg_1 IS TOPIC OF Arg_2	*weather#1/Arg_1 report#2/Arg_2*
16	MANNER	Arg_1 IS MANNER OF Arg_2	*performance#3/Arg_2 with passion#1/Arg_1*
17	MEANS	Arg_1 IS MEANS OF Arg_2	*bus#1/Arg_1 service#1/Arg_2*
18	EXPERIENCER	Arg_1 IS EXPERIENCER OF Arg_2	*the fear#1/Arg_2* of the girl#1/Arg_1
19	MEASURE	Arg_2 IS MEASURE OF Arg_1	*inches#1/Arg_2 of snow#2/Arg_1*
20	TYPE	Arg_2 IS A TYPE OF Arg_1	*framework#1/Arg_1 law#2/Arg_2*
21	THEME	Arg_1 IS THEME OF Arg_2	*acquisition#1/Arg_2 of stock#1/Arg_1*
22	BENEFICIARY	Arg_1 IS BENEFICIARY OF Arg_2	*reward#1/Arg_2 for the finder#1/Arg_1*
		OTHERS	*cry of death*

xli. Figure representing Girju's 22-SR set, from (Girju, 2009, p. 193)

For example, Girju's experiment (2009a) revealed human mark-up BY for the SR Agent in the NNC="member request". Human annotators identified markers OF, FOR, IN and BY to be associated to this SR, as shown in table xxxix. Thus, a key assumption will be that the group of candidate prepositions is treated under a "multiple meaning" approach-like. This is to say, all prepositions in the clusters will develop internal links within a prepositional SR network, as follows:

OF(Agent)=FOR(Agent)= IN(Agent)=BY(Agent)

xlii. Formula representing a multiple meaning approach between prepositions in a cluster associated to the SR Agent.

For convenience, the "=" sign means replaceable membership to the cluster. For instance preposition BY(Agent) will therefore be chosen as a unique identifier for above SR Agent to make preposition cluster uniquely distinguishable. BY(Agent) and BY(Means), will differ in the type of leading SR they were annotated from.

They were assigned, however, the same preposition cluster under the "multiple meaning" proposal (Kidd, 2008).

A remark about prepositions IN, ON, and AT will be made to clarify semantic mark-up. From empirical evidence across corpora in Lauer's work –Grolier Encyclopaedia- as well as Girju's work –Europarl, and CLUVI-, SR Temporal for IN, ON, AT prepositions, SR Location for IN, ON, AT preposition and SR Location for IN, ON, AT prepositions will be assigned a unique identifier.

Intuitively it will be assumed that the preposition IN will represent a SR Temporal across the present set of prepositions, even though ON or AT might be preferred. For instance, NNC="weekend party", which is likely to be paraphrased "party ON(Temporal) weekend(s)", will be represented by "party IN(temporal) weekend(s)", due to the "multiple meanings" assumptions. Likewise, it will be assumed preposition ON will be represented by a SR Location, and preposition AT will imply a SR Location as well. The way table xliii was built involved the 22-SR table xli from the Girju's analyses. In table xliii below, the main prepositions processed as a result of these assumptions are shown:

Girju's SR	Manually- annotated	"Multiple meaning" identifier	In Lauer's set?
Possession	of	of(possession)	☑
Kinship	of	of(kinship)	☑
Property	of, for, in	of(property)	☑
Agent	of, for, in, by	by(agent)	☒
Temporal	of, on, in, at,	in(temporal)	☑
Depiction	of	of(depiction)	☑
Part-whole	of, in, with	of(part-whole)	☑
Is-a (hypernym)	of, with	of(is-a)	☑
Make/produce	of, for, in, from	of(make)	☑
Instrument	for, with	with(instrument)	☑
Location	of, on, in, at	at(location)	☑
Purpose	of, for	for(purpose)	☑
Source	of, from	from(source)	☑
Topic	of, for, on, about	about(topic)	☑
Manner	with	with(manners)	☑
Experiencer	of, in	of(experiencer)	☑
Measure	of	of(measure)	☑
Theme	of, for, in	of(theme)	☑
Beneficiary	for	for(beneficiary)	☑

xliii. Chart representing Girju's mappings with wildcard preposition scheme

From the table above, it can be seen that an extra preposition has been consistently surfacing throughout Girju's analysis. The preposition BY represents 7.47% in the Europarl analysis, while it represents 6.23% in the CLUVI sample. It is substantially represented compared, for example, to the preposition OF(Part-whole) in the same analysis, which is 3.20%.

Because of this statistical significance within the token sample, this work has decided to include the preposition BY as available paraphrasing in the semantic rules of the AXEL System. According to above observation, the preposition table will include nine prepositions. The effects of adding an extra preposition will have no further impact on the Evaluation phase as Lauer's test does not give estimates for preposition BY. The table below shows the nine-preposition paraphrasing for this dissertation:

Lauer Preposition	"Multiple meaning" Identifier	In Lauer's set?
OF	of(property), etc.	☑
FOR	for(purpose), etc.	☑
WITH	with(instrument), etc.	☑
IN	in(temporal)	☑
ON	at(location)	☑
AT	at(location)	☑
ABOUT	about(topic)	☑
FROM	from(source), etc.	☑
BY	by(agent), etc.	☒

xliv. Table representing preposition mapping between Girju's SRs and Lauer's Prepositions

The next section will detail the implementation of Use-Case "apply-PWOP-mappings", which is critically instrumental towards the development of the AXEL System.

5.2.2. Heuristics

This section will build the semantics of interpretability, which will rest upon the heuristic interaction between type inheritance, lexical hierarchies and mappings from section 5.2.1.

These paragraphs will constitute the practical work towards testing, as a supervised experiment will be planned as the main evaluation approach. Under this assumption, a training set will be required (Navigli, 209). The training set will be assembled in terms of a few examples from the Girju's analyses. Due to time constraints, the training set will be made up of such a handful of manually sense-tagged structures from Girju's tables xxxix, xl and xli.

The next detailed discussion will argue that the Girju's prepositional rules can provide computational grounding for Use-Case "apply-PWOP-mappings" of the AXEL System.

For convenience, only one SR will be expounded in detail in this section. However, the rest of the SRs and their contribution to the bulk of prepositional paraphrasing will be documented in Appendix D. In order to use the same terminology as Girju's work, this dissertation has changed symbols in the formula xi as follows:

$$\mathbf{(MN_1+MN_2)+HN= (Arg_1+Arg_2)+Arg_3}$$

xlv. Formula based on formula xi , representing a left-branching Construct approach using conventional Girju's terminology.

Each SR in table xli will be analysed under the following heuristic assumption:

> **Assumption 1.-** Given any Arg_1+Arg_2 noun compound in Girju's set in table lix associated to a SR_i, (i=1, …, 22), it will always exist unique universal simple types $T(Arg_1\text{-}Sense_j)=Ti_1$ and $T(Arg_2\text{-}Sense_k)=Ti_2$, (j=1, …,N, k=1, …,M) as queried from the knowledge base WordNet. T is the abstract transformation in formula liv. Such Ti_1, and Ti_2 simple types implies aforementioned SR_i and vice versa.

The assumption above attempts to conduct the overall discussion to finding simple types associated to each noun constituent under a specific SR. This effect will define a SR in terms of those simple types Ti_1, Ti_2, which will determine such SR.

The first heuristic rule to the paraphrasing semantics will determine Ti_1, Ti_2 under the particular SR. This will have the effect to define a SR in terms of those universal simple types Ti_1, Ti_2. This is halfway to the heuristics for establishing a paraphrasing mechanism out of the lexical hierarchies or syntactic information. So to speak, a second assumption is needed:

> **Assumption 2.-** Ti_1, and Ti_2 simple types from Assumption 1 can always be conflated into a new simple type $Ti_{1+2}=Ti_1+Ti_2$, under the aforementioned SR_i . Resulting simple type Ti_{1+2} is a pruned copy from Ti_2. The extent of pruning for both Ti_1 and Ti_2 is determined by the nature of SR_i.

This second assumption provides the calculi over simple types in the NNC, by privileging the noun constituent to the right. Assumption 2 preserves simple types for the noun constituent to the right, which is the head noun, taking for granted relevance of headedness in NCs.

This is to say, this dissertation will advocate the view that the right noun constituent determines the most important piece in the NC structure. For example, NC= “death case driver” is an interpretation primarily about a “driver”.

Despite the relevance of the head noun, also pruning of Ti_1 is needed, since it determines the amount of restricted selection between both Ti_1 and Ti_2.

Assumptions 1 and 2 hint heuristics regarding simple types, as this dissertation attempts to experiment with empirical typing of the GLT. However, such

assumptions are only meant to be the beginning of search mechanisms through the present solution space (Dasgupta, 1992).

Such search approach has been adopted to formulate the paraphrasing semantics acknowledging that the selection of Operators in a designer's knowledge base accounts for the novelty of the Design D and, most importantly, proposes a "Tentative Solution" (Dasgupta, 1992).

Tasks of processing prepositional paraphrasing are divided into two subtasks: 1)determining Ti_1, and Ti_2 under SR_i and 2)determining the resulting pruned Ti_1, Ti_2 under SR.

Ultimately it is deliberate that assumption 2 results in a simple type –pruned simple type Ti_2- in order to be processed as the pair Ti_{1+2},Ti_3, under a new SR_j, as input of the second recursive call of Use-Case "apply-PWOP-mappings".

The next paragraph develops the heuristic rules for SR Possession, the rest of the analysis, however, has been moved to Appendix D:

⌦ **1.- SR Possession in Girju's table xli:** The analysed noun compound for the SR Possession in Girju's table is NNC= "family estate". Such structure is represented by Arg_1+Arg_2, which should be read "Arg_1 Possesses Arg_2" or "family Possesses estate".

The FSBs have been queried from the knowledge base to which T transformation will be applied. The simple types were retrieved as hypernyms for each noun constituent from the knowledge base.

For instance, the lexical hierarchies from WordNet for the head noun Arg_1=family are shown below:

T(Arg_1)=Lexical Hierarchy	Noun	Sense or Gloss
T(family-sense#1)=entity/abstract entity/abstraction/group, grouping/social group/organization/social unit/household	Family	A social unit living together; "he moved his family to Virginia"; "It was a good Christian household"; "I waited until the whole house was asleep"; "the teacher asked how many people made up his home"
T(family-sense#2)=entity/abstract entity/abstraction/group, grouping/social group/kinship group/family unit	family	Primary social group; parents and children; "he wanted to have a good job before starting a family"
T(family-sense#3)=entity/abstract entity/abstraction/group, grouping/social group/kinship group/family tree/lineage/family line	Family	People descended from a common ancestor; "his family has lived in Massachusetts since the Mayflower"
T(family-sense#4)=entity/abstract entity/abstraction/group, grouping/collection/class	Family	A collection of things sharing a common attribute; "there are two classes of detergents"
T(family-sense#5)=entity/abstract entity/abstraction/group, grouping/social group/organization/association/fellowship	Family	An association of people who share common beliefs or activities; "the message was addressed not just to employees but to every member of the company family"; "the church welcomed new members into its fellowship"
T(family-sense#6)=entity/abstract entity/abstraction/group, grouping/biological group/taxonomic group/family-biology	Family	((biology) a taxonomic group containing one or more genera; "sharks belong to the fish family")
T(family-sense#7)=entity/physical entity/physical object/living thing/organism/person/relative/kinsperson	Family	A person having kinship with another or others; "he's kin"; "he's family"
T(family-sense#7)=entity/physical entity/causal agent	Family	A person having kinship with another or others; "he's kin"; "he's family"
T(family-sense#8)=entity/abstract entity/abstraction/group, grouping/social group/organized crime/crime syndicate	Family	A loose affiliation of gangsters in charge of organized criminal activities

xlvi. Table containing lexical hierarchy heuristics for Girju's SR POSSESSION for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=estate is shown in the table below:

T(Arg_2)=Lexical Hierarchy	Noun	Sense or Gloss
T(estate-sense#1)= entity/abstract entity/abstraction/relation/possession/property/estate	Estate	Everything you own; all of your assets (whether real property or personal property) and liabilities
T(estate-sense#2)= entity/abstract entity/abstraction/relation/possession/property/real estate/land	Estate	Extensive landed property (especially in the country) retained by the owner for his own use; "the family owned a large estate on Long Island"
T(estate-sense#3)= entity/abstract entity/abstraction/group, grouping/people/social class/estate of the realm	Estate	A major social class or order of persons regarded collectively as part of the body politic of the country and formerly possessing distinct political rights

xlvii.Table containing lexical hierarchy heuristics for Girju's SR POSSESSION for Arg_2

The present heuristic analysis has influenced a matching for sense 7 from WordNet for Arg_1=family against sense 1 from WordNet for Arg_2=estate. The selection of the present pair of senses has encompassed the closest meaning for

the SR Possession as “A person possesses assets”, according to the knowledge base of “superior” Operators of a Designer (Dasgupta, 1992). The preposition retrieved was OF=OF(possession).

The second part of the semantics acquisition deals with the amount of nodes that must be pruned in the type T(estate-sense#1). By designer’s analysis, the present Operator selection has determined to keep the lexical hierarchy for T(estate-sense#1) up to node “possession”. This is to say, the resulting simple type T(family-sense#7)+T(estate-sense#1) preserved the following lexical pruned hierarchy “entity/abstract entity/abstraction/relation/possession”.

In order to balance off a constraint system of the resulting semantics, the T(family-sense#7) must be pruned up to a semantic level to retain the SR but at the same time to allow more members in the SR. Likewise, by Designer analysis, the present Operator selection has determined to keep the lexical hierarchy for T(family-sense#7) up to node “person”. This is to say, input simple type T(family-sense#7) was considered semantically significant if pruned up to “entity/physical entity/physical object/living thing/organism/person”. SR_1 Possession will be represented by the following:

> **SR_1-POSSESSION RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg1** that contains this part of the simple type from WordNet: **entity/physical entity/physical object/living thing/organism/person/,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/relation/possession/property**, will generate the OF=**OF(Possession)** preposition as underlying SR between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2**: **entity/abstract entity/abstraction/relation/possession/property**,

Basically, the rule above has enabled a “sense of property” between a “person” as a casual agent and “his belongings”. The rest of the semantic rules were included in Appendix D to transparent reading separate from empirical reasoning. In the next section, a summary of all prepositions of paraphrasing semantics will be presented and briefly discussed.

5.2.3. Prepositional Paraphrasing Mappings: Summary

This section will present a table structuring main paraphrasing rules, after they have been argued in section 5.2.2, providing for computational means to implement semantic rules in the Use-Case “apply-PWOP-mappings”. The entries of table xlvi have detailed the prepositional paraphrasing along with its simple types. Basically, the 4^{th} and the 5^{th} columns containing simple types illustrate the ideally pruned lexical hierarchies that guarantee meaningful links in the SR. Three SRs from table lxi were scrapped from paraphrasing resources due to complexities in the type inheritance system. The details below argue the reasons to remove these following three SRs: SR Cause, SR Means, and SR Type.

SR CAUSE is not self-referenced in terms of lexical hierarchies. Some hyponyms node relations were necessary to entail system causation in order to produce a meaningful new type system. For instance, Arg_1=entity/…/abstraction/x_1 /…/x_n, and Arg_2=entity/…/abstraction/y_1/…/y_m, require each relation “x_n causes y_1”, …, “x_n causes y_m” is verified. This might trouble the present analysis, which results in an unmanageable type of logical entailment.

SR Means as analysed from NC=”Bus Service” did not involve interpretations at a hypernym level, but glosses of hyponyms, in order to justify entailment as a means to do something. This situation might have resulted in unclear semantics derived from SR Means. Finally SR Type did not comply with a left-branching approach, since actually it transposed noun constituent positions, resulting in ARG_1 becoming the most relevant instead. This dissertation is interested, in turn, in NCs and

dealing with methods like those of formula xlv. The table below shows the rest of the mappings:

Girju's SR	NNC="Arg_1 Arg_2"	Pruned(Ti_1)	Pruned(Ti_1+Ti_2)	Lauer's Preposition
Possession	Arg_1=family + Arg_2=estate	entity/physical entity/physical object/living thing/organism/person/	entity/abstract entity/abstraction/relation/possession	of(possession)
Kinship	Arg_1=boy + Arg_2=sister	entity/physical entity/physical object/living thing/organism/person	entity/physical entity/physical object/living thing/organism/person/relative	of(kinship)
Property	Arg_1=lubricant + Arg_2=viscosity	entity/physical entity/	entity/abstract entity/abstraction/attribute/property-basic attribute	of(property)
Agent	Arg_1=police + Arg_2=investigation	entity/abstract entity/abstraction/group-members/ or entity/physical entity/physical object/living thing	entity/abstract entity/abstraction/psychological feature/event/human action	by(agent)
Temporal	Arg_1=morning + Arg_2=news	entity/abstract entity/abstraction/measure/fundamental-quantity/time-period	entity/abstract entity/abstraction/psychological feature/event	in(temporal)
Depiction	Arg_1=niece + Arg_2=picture	entity/physical entity/physical object	entity/physical entity/physical object/whole/artifact/creation/representation	of(depiction)
Part-whole	Arg_1=child + Arg_2=face	physical entity/causal agent/entity/physical entity/physical object	entity/physical entity/thing/part	of(part-whole)
Is-a	Arg_1=daisy + Arg_2=flower	entity/x_1/x_2/…/x_n/…/x_{k+n}	entity/x_1/x_2/…/x_n	of(is-a-kind-of)
Make/produce	Arg_1=chocolate + Arg_2=factory	entity/physical entity/substance/ or entity/physical entity/physical object	entity/physical entity/physical object/whole/artifact/construction/building complex/industrial plant	of(make-produce)
Instrument	Arg_1=laser + Arg_2=treatment	entity/physical entity/physical object/whole/artifact/instrumentality/device-invented	entity/abstract entity/abstraction/psychological feature/event/human action/activity	with (instrument)
Location	Arg_1=desert + Arg_2=castle	entity/physical entity/object, physical object/location	entity/physical entity/physical object/whole/artefact	in(location)
Purpose	Arg_1=nail + Arg_2=brush	entity/physical entity/thing/	entity/physical entity/physical object/whole/artifact/instrumentality/implement-tool used to effect an end	for(purpose)

Source	Arg_1=grapefruit + Arg_2=oil	entity/physical entity/thing/.../X where Arg2 contains the substring "X=produce", etc.	entity/physical entity/…/Y where Arg1 contains the substring Y="obtained from X", etc.	from(source)
Topic	Arg_1=weather + Arg_2=report	entity/physical entity/physical process/phenomenon	entity/abstract entity/abstraction	About(topic)
Manner	Arg_1=passion + Arg_2=performance	entity/abstract entity/abstraction/attribute	entity/abstract entity/abstraction/psychological feature/event/…/X, Were substring X paraphrases "performing, doing, addressing" etc. activities	with(manner)
Experiencer	Arg_1=girl + Arg_2=fear	entity/physical entity/physical object/living thing	entity/abstract entity/abstraction/attribute/state/feeling	of(experiencer)
Measure	Arg_1=snow + Arg_2=inches	entity/abstract entity/abstraction/measure	entity/physical entity/physical object	of(measure)
Theme	Arg_1=stock + Arg_2=acquisition	entity/abstract entity/abstraction/.../Y where Y is implied by a subsystem string from Arg1, for instance "acquisition" from type system of Arg2, and "acquired, owned" from type system of Arg1	entity/abstract entity/abstraction/.../X where X substring implies Y from Arg2. for instance "acquisition" from type system of arg2, and "acquired, owned" from type system of Arg1	of(theme)
Beneficiary	Arg_1=finder + Arg_2=reward	physical entity/physical object/living thing/organism/person	entity/abstract entity/abstraction/communication/message/offer/ or entity/abstract entity/abstraction/relation/possession-anything owned/transferred property/acquisition/gift	for(beneficiary)

xlviii. Table representing prepositional paraphrasing fulfilling the semantics of the AXEL System.

The table above summarised the simple types to provide the input for the PWOP Models, which will assist in the development of the AXEL System.

5.2.4. Implementation of Artefact A

This section will summarise requirements to implement semantic rules, recursive programming, and notions of meaning association in development of the AXEL System.

The programming requirements from diagram xxxvii will be coded using mainstream data structures and algorithms to create the AXEL System. Vaishnavi's viewpoint (2004) will prevail in this dissertation to guide development efforts advocating for novelty in Design, instead of novelty in artefact construction. The present dissertation will not discuss code issues in depth. The only reference to code is the set of variable definitions to illustrate semantic differences in the iterations of the Artefact A, which has been included in Appendix C.

The Design D will undergo a second iteration having impact at paraphrasing levels only showing that Use-Case "apply-PWOP-mappings" will involve the only changes in the whole of the Design D. A sequential set of pseudo code steps has been outlined below to describe the prepositional paraphrasing implementation of this dissertation:

- **Pseudo Code Step 1:** Generate syntactic input from WordNet –manual interface- to provide Argument elements (Use-Cases "generate-text-output-via-GUI-per-noun" and "transfer-lexical-hierarchy-text-into-spreadsheet".).
- **Pseudo Code Step 2:** Read NNNC structure and retrieve syntactic information and lexical hierarchy structures (Use-Case "retrieve-lexical-hierarchy-per-sense").
- **Pseudo Code Step 3:** Select first pair of nouns, modifier-noun$_1$ modifier-noun$_2$. i.e. Arg$_1$+ Arg$_2$ (Use-Cases "select-Noun-Modifier-Noun-Modifier").
- **Pseudo Code Step 4:** Assemble multiple senses to process simple type arrangements from noun input into a cartesian product X for sense combination (Use-Case "form-sense-cartesian-product).

⌦ **Pseudo Code Step 5:** Work out paraphrasing to deliver semantic rules and simple type output, for each type NNC in Pseudo Code Step 4 (Use-Case "apply-PWOP-mappings").

⌦ **Pseudo Code Step 6:** Asses stop criteria on PWOP prepositions to flag valid paraphrasing and format paraphrasing data structures (Use-Case "deliver-PWOP-preposition-and-lexical-hierarchies-table" and).

⌦ **Pseudo Code Step 7:** Select second pair of nouns, modifier-noun$_2$ head noun i.e. Arg$_2$+ Arg$_3$ (Use-Cases "select-Noun-Modifier-Head-Noun").

⌦ **Pseudo Code Step 8:** Repeat Pseudo Code Step 4, 5 and 6.

⌦ **Pseudo Code Step 9:** Connect PWOP prepositions and prepositional data structures with index processing to deliver IOF and ODOF measures (Use-Case "work-out-integration-ontological-distinctness-measurement".)

This collection of pseudo code steps structurally constitutes the 4th Artefact –the AXEL System- of this dissertation, according to diagram vi in Chapter 2.

A chapter summary will be documented in the next section to reflect on the development process and its experience.

5.2.5. Chapter Summary

The major contributions of this chapter were oriented to the practical Development of the AXEL System from a secondary point of view, which has been implemented, however, as comprehensive study according to the elements of the methodology (Blessing, 2009). Primarily, the objective of this chapter was to argue the semantic elements of the AXEL System from a Design viewpoint. This quickly shifted the efforts to define and investigate the characterisation of the internal semantics,

rather than informing detailed coding tasks. Intuitively, this argues the relevance of the Design is not based on coding, but on the Design itself (Vaishnavi, 2004)

A part of the supervised approach of the Evaluation phase was introduced in the section 5.2.2. The approach will be carried out in the next chapter, when referring therefore to the hand-coded analysis of the Girju's rules in table xli. The major undertaken challenges involved the discussion of algorithms for the semantics and prepositional rules of the AXEL System. The present mappings to be used throughout coding were summarised in table xlvi, which connects the Girju's tables and the Lauer's prepositions.

The Use-Case diagram intended to connect an experience of practical implementation and theoretical Design, as guidance to using specifications of language design to inform a process, otherwise largely vague. The collection of Use-Case requirements helped specify the main functionality of the AXEL system in pseudo code components to provide quick assistance at coding time.

This chapter coded the AXEL System as a transparent layer to the reader, in order to speed the reading to assist in the processes of critically understanding the present solution. For this very reason, the discussion of the repetitive structures regarding the semantics in section 5.2.2 was documented in separate Appendix D. the approach illustrates the semantic patterns in the internal organisation of the prepositional force of the Dynamic Construal of Meaning framework.

In the next chapter, testing will be undertaken to evaluate the performance measures and carry out the iterative performance-solving approach.

6. EVALUATION

6.1. TEST SET PREPARATION

6.1.1. Introduction

This chapter will undergo semi-automatic testing for the AXEL System developed in Chapter 5. This assessment ultimately will aim to compare the prediction capacities of the AXEL System against well-known results from the Literature. Regarding rework due to iterations, Use-Case diagram xxxvii will assist in an iterative fashion towards performance-improving after the first performance measures assessment.

Though, the training set has been annotated based only on a handful of cases from Girju's tables due to time constraints, the implementation has been intended as a structurally supervised model.

The Lauer's set (1995a) from the Literature contains NNC and NNNC instances. Unsurprisingly, the present implementation effort shall break down Lauer's test, into NNC and NNNC models to achieve results. Consequently, a total of two experiments –first NNC, and secondly NNNC- will be set up to convey the present evaluation. The first scenario will deal with NNCs only. At this point, testing will cope with NNC paraphrasing, which will deliver figures to assess the accuracy of compounding interpretation. Afterwards, the second scenario will prepare two interrelated environments to deal with NNNCs. The first part is to be responsible for handling performance of left-branching bracketing. The second part is to provide automatic paraphrasing in terms of preposition pairs to lead to classification of polysemic behaviours of NCs.

The next section will explain the details of the architecture of the AXEL System to prepare the two experiments for NNCs and NNNCs.

6.1.2. The software

The current collection of software tools used to fulfil the evaluation happens to be a key element to understanding the nature of the present test. The Artefact A involved two programming stages.

External sources provided files to the AXEL System by involving WordNet as the file provider. Though, WordNet presents an interface which is reachable via API calls, due to time constraints this dissertation adopted a cut-and-paste approach. The access to lexical hierarchies or hypernyms associated to the noun constitutes from the source files is manually provided by the WordNet GUI. The data structures are then transferred to Excel spreadsheets. The version of the WordNet packages was the Windows-based WordNet 2.1 (Princeton University, 2010).

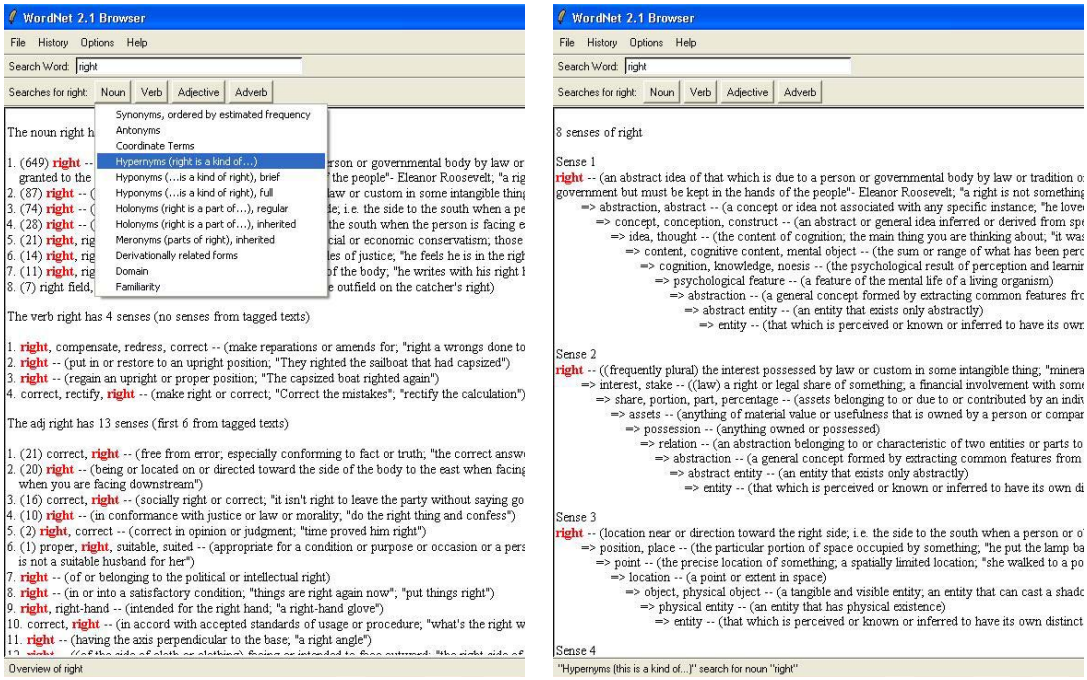
A second task coped with the processing of sources within the AXEL system. To this end, the application –developed according to Use-Case Diagram xxxvii from Chapter 5 and coded in Excel VBA for applications- is to receive spreadsheets to process NC information. Following the spreadsheet input, the AXEL System transforms Excel-based data into prepositional paraphrasing. The AXEL interface allows the processing of either NNCs or NNNCs.

6.1.3. The WordNet Searching Interface

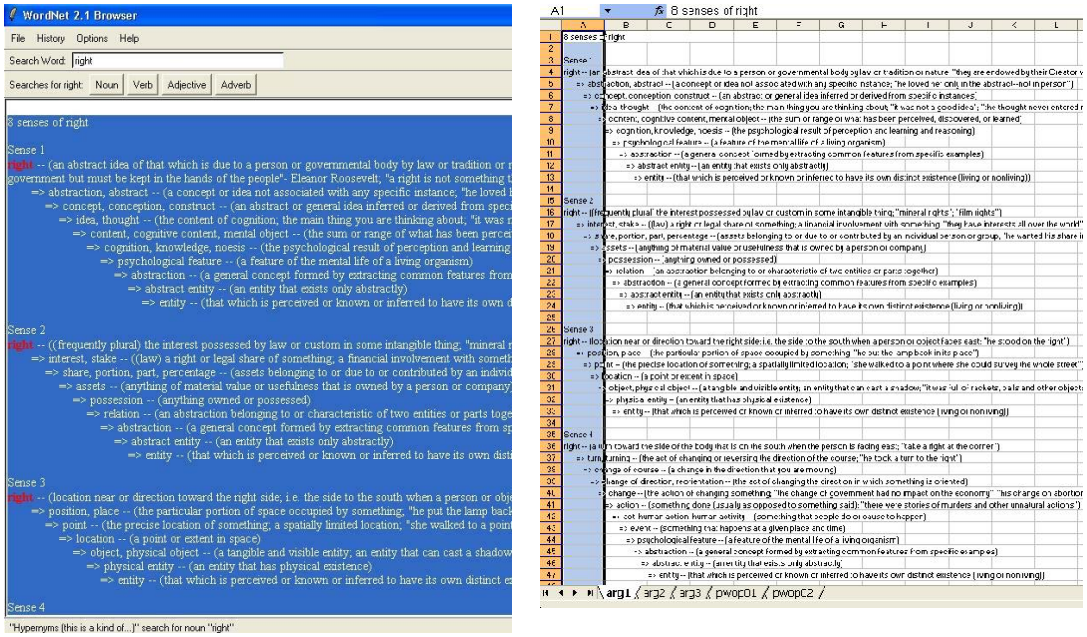
File generation as part of data input of the AXEL artefact is accomplished in two stages. The first stage deals with the search of lexical hierarchies in WordNet, whilst the second one copes with data transfers into spreadsheets by cut-and-paste.

In the first stage, the actor Noun Compound User must type a noun particle in the WordNet GUI to display noun contents and syntactic categories sorted by sense and lexical hierarchies –hypernyms. The second stage involves text output cut-and-paste from WordNet. Lexical hierarchies will be rendered in the WordNet lower window as text to be taken by the actor Noun Compound User, who will manually

create spreadsheets transferring syntactic noun information. As a result, NNNC input will be stored in a spreadsheet holding information for Arg_1, Arg_2, and Arg_3. The AXEL System will deliver output formatted as spreadsheet-based data, containing prepositional interpretation and association indexes IOF and ODOF.

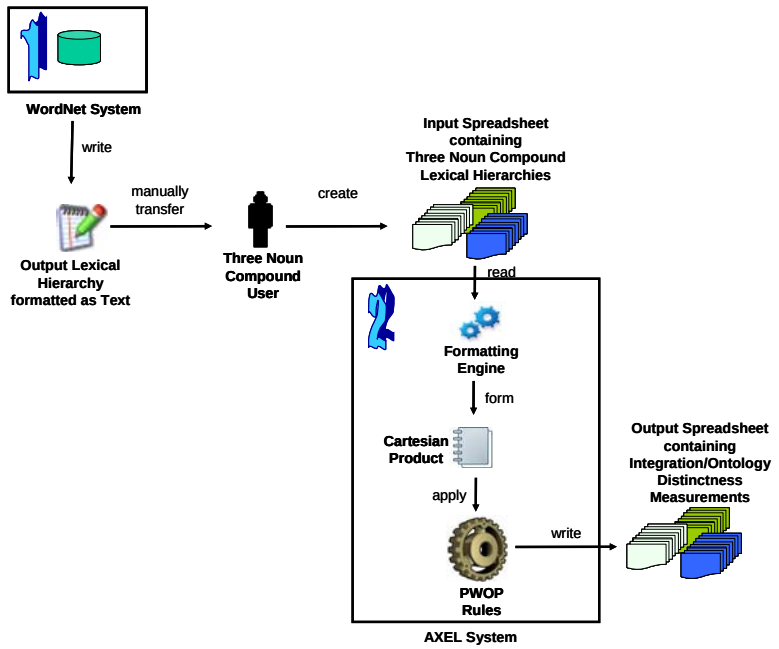


xlix. Chart showing WordNet menus for retrieving lexical hierarchies associated to search for noun "right"



l. Chart showing Excel spreadsheet input for the noun "right" as transferred from the WordNet GUI

Interactions of the elements of the AXEL system can be described below to illustrate processing:



Ii. Chart showing main processing flow in the artefact development, divided into two stages: 1)manual WordNet output and 2)automatic PWOP AXEL calculations

The picture above revealed the AXEL System is a semi-automatic tool as manual transfers of lexical hierarchies were deliberately involved.

6.1.4. The Supervised Model

This dissertation aims to specify the scope of a training set and a test set for the present evaluation exercise, as key components of efforts in terms of a supervised model (Navigli, 2009). A supervised model can be defined as a machine-learning technique –the AXEL System for this evaluation exercise- that learn a classifier – manually sense-annotated paraphrasing for this evaluation exercise- from labelled training sets – analysed SRs by Girju's.

The training set was manually annotated by Girju (2009a, p. 202) in an earlier experiment, from which as already mentioned, a few results were taken from tables xxxix, xl xli. Analysis by the Designer constituted the classifier in the supervised

model –aka the word expert. The training set accounted for a handful of examples from tables xxxix, xl and xli. Typically in the literature the training set is a set of examples in which a given relation or word is manually tagged (Navigli, 2009). The present dissertation did not manually tag the whole Girju's set, due to time constraints.

Treatment of the training set was covered in chapter 5, at which point deep analysis of lexical hierarchies was carried out to build semantics, as shown in Appendix D. Details of token assembly in the training sets must have to be referred to the Girju's experiment (2009a).

The second part of the supervised Model is the test set. NC Collections from random samples of the Grolier encyclopaedia were transcribed from Lauer' PhD thesis (1995a). Lauer's sets are a widely-known experiments in the literature for testing, accounting for: 1)NNC and 2)NNNC collections.

6.1.5. The Two-noun Compound Set

This section will deal with the partitioning of the Lauer's set to address the scenarios for NNCs. First, the number of target compounds for the this test in the two-noun collection is 275. Though, the original Lauer's random sample was made up of 400 noun compounds.

The present test removed 25 noun compounds out of 400 that happened to be duplicates in the collection, so that it made the set less redundant. Also as many as 14 records or some 3.7% of noun compounds were left out as they were reported as errors in Lauer's exercise. Likewise, 59 records classified as nominalisations were scrapped as they do not contribute to prepositional paraphrasing, but verbal semantics. Also as many as 27 noun compounds were removed due to probable conflict annotation due to the "multiple meaning" proposal.

For example, the noun compound SUNDAY RESTRICTION was assigned the correct preposition ON, according to Lauer. However, this research considered IN(TEMPORAL) the right-on encoding, as it is posing unambiguous paraphrasing RESTRICTION IN(TEMPORAL) SUNDAY= RESTRICTION ON SUNDAY. Otherwise ON paraphrasing in Lauer's compound might have been confounding with ABOUT paraphrasing in the AXEL framework.

To avoid manipulation in restating Lauer's encoding, this dissertation proceeded with elimination of such NCs. By deleting some 6.7% of problematic encoding, this dissertation intended to stop manually sense-annotated intervention. The following table shows deleted preposition encoding for the aforementioned subset:

Modifier Noun	Head Noun	Two-noun Compound	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	Type of Nominal Compound	Correct Preposition Originally paraphrased by LAUER
COUNTRY	MUSIC	COUNTRY MUSIC	F		A	noun compound	I
CITY	POPULATION	CITY POPULATION	O		A	noun compound	I
MONKEY	POX	MONKEY POX	O		A	noun compound	I
CATALOGUE	ILLUSTRATION	CATALOGUE ILLUSTRATION	R		A	noun compound	I
CONCERT	APPEARANCE	CONCERT APPEARANCE	A		A	noun compound	I
COUNTRY	ESTATE	COUNTRY ESTATE	A		A	noun compound	I
QUADRANT	ELEVATION	QUADRANT ELEVATION	A		A	noun compound	I
CITY	DWELLER	CITY DWELLER	A		A	noun compound	I
COMMONWEALTH	STATUS	COMMONWEALTH STATUS	A		A	noun compound	I
SEA	**LANE**	**SEA LANE**	**F**	**A**	**A**	**noun compound**	**I**
KIDNEY	**DISEASE**	**KIDNEY DISEASE**	**F**	**A**	**A**	**noun compound**	**I**
MOUNTAIN	**VALLEY**	**MOUNTAIN VALLEY**	**N**	**A**	**A**	**noun compound**	**I**
APARTMENT	**DWELLER**	**APARTMENT DWELLER**	**W**	**A**	**A**	**noun compound**	**I**
THEATRE	**ORCHESTRA**	**THEATRE ORCHESTRA**	**A**	**A**	**A**	**noun compound**	**I**
UNIVERSITY	**EDUCATION**	**UNIVERSITY EDUCATION**	**A**	**A**	**A**	**noun compound**	**I**
UNIVERSITY	**TEACHER**	**UNIVERSITY TEACHER**	**A**	**A**	**A**	**noun compound**	**I**
STREET	SCENE	STREET SCENE	F		A	noun compound	N
COMPUTER	CATALOGUE	COMPUTER CATALOGUE	O		A	noun compound	N
ROAD	COMPETITION	ROAD COMPETITION	R		A	noun compound	N
VASE	PAINTING	VASE PAINTING	A		A	noun compound	N
FRONTIER	PROBLEM	FRONTIER PROBLEM	A		A	noun compound	N
FRONTIER	COMMUNITY	FRONTIER COMMUNITY	A		A	noun compound	N
SUNDAY	RESTRICTION	SUNDAY RESTRICTION	I		I	noun compound	N
EAVES	**TROUGH**	**EAVES TROUGH**	**O**	**A**	**A**	**noun compound**	**N**
WEAPON	**POLICY**	**WEAPON POLICY**	**T**	**T**	**T**	**noun compound**	**N**
MYSTERY	**NOVEL**	**MYSTERY NOVEL**	**T**	**T**	**T**	**noun compound**	**N**
MOUNTAIN	**GLACIER**	**MOUNTAIN GLACIER**	**F**	**A**	**A**	**noun compound**	**N**

Iii. Table showing deleted ambiguous preposition encoding for NCs in the test set

The last row of below table Ii shows Lauer (1995a) also has annotated an extra type of compounds called copula compounds, with B paraphrasing.

A copula compound B corresponds to a SR is-a-hypernym in Girju's table xli, and were undoubtedly part of the prediction work by Lauer (1995a). Due to this addition the following table was need to be encoded to include copula mappings for testing:

Preposition Type	Lauer-encoded Preposition	Axel-encoded Preposition	Encoded Semantic Relation	In Lauer's Set?
OF	O	O	of(property), etc.	☑
FOR	R	R	for(purpose), etc.	☑
WITH	W	W	with(instrument), etc.	☑
IN	I	I	in(temporal)	☑
ON	N	A	at(location)	☑
AT	A	A	at(location)	☑
ABOUT	T	T	about(topic)	☑
FROM	F	F	from(source), etc.	☑
BY	Y	Y	by(agent), etc.	☒
IS-A (HYPERNYM)	B	B	of(is-a-kind-of)	☑

liii. Table showing changes to preposition encoding to be used in the test set

Appendix A contains all 275 NNCs transcribed from Lauer's thesis (1995a). Such a table additionally has displayed AXEL prepositional predictions to compare results from both Lauer and AXEL approaches.

6.1.6. The Three-noun Compound Set

This section will deal with bracketing. Although, the AXEL System does not cope with bracketing, it has approached it at a review-based level. The underlying assumption of this test is that the AXEL System holds a necessary condition for left-branching features.

This is to say, if the NC is a left-branching AXEL NC, then both Prepositions PWOP1 and PWOP2 –recursive paraphrasing- are delivered. The logical contrapositive of the conditional of this implication is: if at least one of the prepositions PWOP1 and PWOP2 is not worked out, then the NC is not a left-branching AXEL NC.

Even more, in terms of the Proposal –the 2nd deliverable of this dissertation- the 3rd Performance Measure established that either null PWOP1 or null PWOP2 will be

used as a criteria to stop the calculations in the AXEL System. Roughly this will define a performance measure for testing success as follows:

> ⌦ **1st Performance Measure in the AXEL System- Prepositional Ways of Paraphrasing Model:** If at least one of the Prepositions PWOP1 and PWOP2 is not delivered by the AXEL System, then the NC cannot be marked as left-branching.

This performance measure settles a conventional criterion for testing partial bracketing against Lauer's set.

The present characterisation of the NNNC set is entirely different from that of the NNC set and will assist in understanding two tasks: 1)left-branching bracketing issues, and 2)the NNNC association index in the corpus. The Lauer's test did not process interpretation for NNNCs. As a consequence, the present test has not assessed interpretation for NNNCs either, as Lauer's test did not supply figures for comparison.

Some criteria are therefore needed to test the success of the AXEL system for the second task of association of meanings. According to diagram vi, such performance measures need to be defined as follows:

> ⌦ **2nd Performance Measure in the AXEL System- Degree of Association Model:** If both Prepositions PWOP1 and PWOP2 are delivered, the AXEL System will provide a pair of numbers (IOF=N, ODOF(M_1, …, M_N)), which allocate the NC into any possible scenario from the Proposal Artefact: 1)Scenario I-AXEL NC, 2)Scenario II- monosemous NC, 3)Scenario III-polysemic NC and 4)Scenario IV- extremely polysemic NC.

Following the digression and getting back to the test, the present set will include 130 instances of NNNCs extracted from Lauer's original random set of 308 NNNCs, as produced from Grolier encyclopaedia.

The present approach has removed 178 instances due to unsuitable bracketing. For a meaningful comparison, the present subset includes only those 130 instances that were assigned left-branching analyses. The Chosen instances have been coded as L, since the AXEL System gives no account for any type of bracketing, but left-branching. Since the Lauer's paraphrasing included extra categories in his learning exercise - right-branching (R), indeterminate branching (I) and extraction error (E)- the AXEL System has included L bracketing and I bracketing. The latter is mainly for dealing with indeterminate bracketing for unexplained instances within the test set.

This NNNC test has not provided paraphrasing, since its main goal is to measure bracketing capacities only. Since the original Lauer's set just displayed all 130 instances with no SR or prepositional paraphrasing at all. Appendix B contains all 130 NNNCs as transcribed from Lauer's dissertation (1995a).

A table in Appendix B has included 1)AXEL predictions for left-branching encoding, 2)PWOP paraphrasing and 3)indexes for Integration and Ontological Distinctness, in order to assist in the comparison of results from left-branching approaches. The same prepositional encoding from the NNC test has been used for prepositional interpretation.

In the following section, approaches to testing both NNC and NNNC algorithms, are described in detail, and the results are analysed in order to suggest improvements for the AXEL System.

6.2. ARTEFACT ASSESSMENT

6.2.1. Experiment on NNC Interpretation

In this section, the main goal is to test semantic NC interpretations in terms of preposition paraphrasing. This dissertation has implemented a supervised model for the AXEL System to work out the prepositions called PWOPs to provide NC semantics.

The NNC Lauer's set has been analysed via an unsupervised probabilistic model that features a general class of statistical language learners.

The Lauer's approach is entirely probabilistic and conveys the findings of the most likely prepositional paraphrase $\mathbf{P^*=arg\text{-}max_p P(p|n_1,n_2)}$ (Girju, 2009, p. 487). His problem is stated as a selection problem (Lauer, 1995a).

In contrast, the AXEL System conveys a Symbolic Paradigm approach that uses compositional autonomy concepts to come up with a multiple set of prepositions – possibly one- for solving a generative problem.

This is to say, the output will include all senses for NCs with prepositional paraphrasing as interpreted by the internal semantics of the application. The problem for the AXEL System is then stated as a generative problem.

Thus the criterion to evaluate both experiments has been provided below:

> ⌦ **3rd Performance Measure in the AXEL System-Constraint Model and the Prepositional Ways of Paraphrasing Model:** If the first Preposition PWOP1 is delivered by the AXEL system, in conjunction with deprecation of contextual constraints, the generative approach will deliver possible more than one preposition. A PWOP1 set is considered a successfully predicted match for

the correct preposition, if the right preposition is in the set of all PWOP prepositions delivered by the AXEL System. This is to say, as long as the right preposition is in the generated set, the AXEL System scores a successful preposition match.

The AXEL System has been fed with 275 NNCs to know which the correct preposition is associated to the NNC. As long as, the generative set of prepositions contains the correct preposition from Lauer's set, the AXEL artefact acknowledges a prepositional interpretation match.

The table below contains the criteria to evaluate a successful AXEL System, which accounts for the 5th deliverable of this dissertation. The table summarises the earlier performance measures as follows:

Model Involved	Task to Evaluate	Description
Prepositional Ways of Paraphrasing Model	Left-branching in NNNC sets	1st Performance measure: If at least one of the Prepositions PWOP1 and PWOP2 is not delivered by the AXEL System, then the NC cannot be marked as left-branching.
Degree of Association Model	Association index interpretation in terms of IOF and ODOF for NNNC sets	2nd Performance measure: If both Prepositions PWOP1 and PWOP2 are delivered, the AXEL System will associate a pair of numbers (IOF=N, ODOF(M1, …, MN)), which allocate the NC into any possible scenario from the Proposal Artefact: 1)Scenario I-AXEL NC, 2)Scenario II- monosemous NC, 3)Scenario III-polysemic NC and 4)Scenario IV- extremely polysemic NC.
Constraint Model and Prepositional Ways of Paraphrasing Model	Paraphrasing interpretation for NNC sets	3rd Performance measure: If the first Preposition PWOP1 is delivered by the AXEL system, in conjunction with deprecation of contextual constraints, the generative approach will deliver possible more than one preposition. A PWOP1 set is considered a successfully predicted match for the correct preposition, if the right Grolier preposition is in the set of all PWOP prepositions delivered by the AXEL System. This is to say, as long as the right Grolier preposition is in the generated set, AXEL System scores a successful preposition match.

iv. Table showing Performance Measures Artefact for the AXEL System regarding formulation of criteria to evaluate artefact success

In the next section, this research will contrast experimental results in order to prepare its way for a second iteration to revamp the first tentative solution.

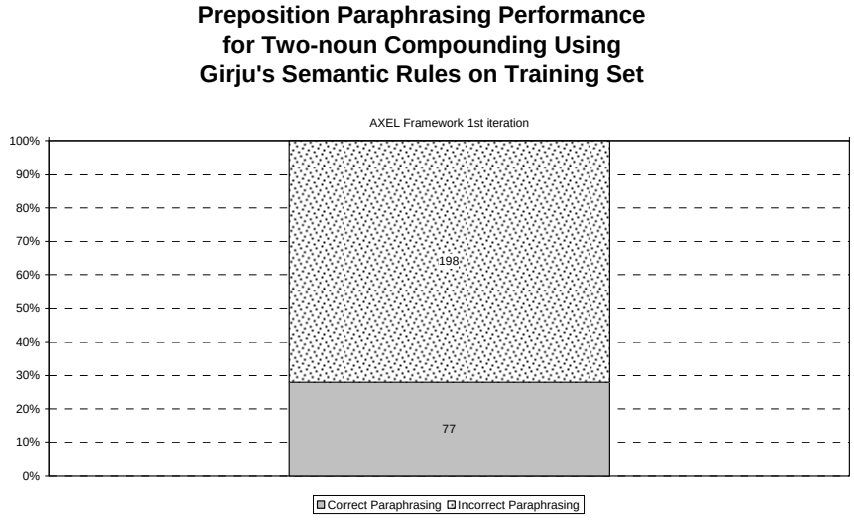
6.2.2. Two-noun Compound Results of the First Iteration

The AXEL model was tested on the Lauer's set of 275 NNCs. The results obtained shows that a total 77 out of 275 noun compounds were assigned the right preposition based on the 3rd Performance Measure of table liv.

The total amount of instances represents 28% accuracy, which has been computed as the number of correct instances divided by the total number of instances in the test set.

Result comparison suggests the AXEL System might be improved. Due to the nature of the DR methodology this dissertation was able to quickly carry out extra iterations. Improving of the response of the AXEL System will attempt to understand the impact an extra iteration might have on the performance of the Tentative Design D. By doing so, the present methodology is meant to recognise that a better theory or a better way of explaining behaviours is largely ongoing in the next section.

The results for this test are shown in the following chart, where the solid sector represents the amount of correctly labelled instances:



Iv. Chart showing the performance by the supervised AXEL model on the Lauer's test set

6.2.3. Iterations for the Two-noun Compound Experiment

Results from section 6.2.2 showed a poor performance towards NC interpretation by the AXEL System. This section attempts to investigate if 28% accuracy measure shall reflect areas of improvement. To this end, a second iteration focusing on manually sense-annotated improvements will be attempted.

According to diagram vi, any extra iterations will start out at the Development phase. This will have the effect to leave the Tentative Design D unchanged, while focusing exclusively on Artefact changes.

The main changes to improve the theory will be carried out at application levels only, leading to a second version of the AXEL System. The incorrectly predicted prepositions from the Lauer's set will help analyses extend the heuristics for improvements to possibly outline better lexical hierarchy knowledge. The analysis as follows:

> ⌦ **Improve on F paraphrasing analysis:** Though F (FROM) PWOP had been already mapped in the training set, remarkably the number of instances matched in the test was zero. By further analysing lexical hierarchies of incorrectly labelled instances, it is apparent some F encoding might have gone missing in the corpus. To this end, the analysis below has enabled a new SR origin or SR provenance, which has enlarged heuristics with the following rules:

Pruned T(Arg_1)	Pruned T(Arg_2)	SR	New?
entity/physical entity/object/living thing	entity/physical entity/substance/material/waste	droppings FROM bird	☑
entity/physical entity/substance	entity/physical entity/object/whole/artifact/creation	product FROM petroleum	☑
entity/physical entity/thing/body of water/sea	entity/physical entity/object/living thing/organism/animal	lion FROM sea	☑

lvi. Table showing new semantically sense-annotated PWOP for F paraphrasing (FROM) towards artefact improvement

⌦ **R paraphrasing analysis:** Though R (FOR) PWOP has been already mapped in the training set, it is apparent heuristics can lead to an increase in the number of instances matched. By further analysing lexical hierarchies of incorrectly labelled instances, formulation of new rules has been indentified to enlarge on one hand, existing semantically annotated categories, namely FOR(purpose) and FOR(instrument). On the other hand, it is also apparent a new category has been necessary for describing skill-specific relations. In order to deal with heuristics changes the following rules have been encoded:

Pruned T(Arg_1)	Pruned T(Arg_2)	SR	New?
entity/physical entity/substance	entity/physical entity/object/whole/artifact/way	duct FOR bile	☒
entity/abstract entity/abstraction/psychological feature	entity/physical entity/object/whole/artifact/facility	museum FOR arts	☒
entity/physical entity/process/natural process/chemical process	entity/physical entity/substance/mixture	mixture FOR reaction	☒
entity/abstract entity/abstraction/psychological feature	entity/physical entity/object/location/region	area FOR recreation	☒
entity/physical entity/substance	entity/abstract entity/abstraction/group/social group	industry FOR food	☒
entity/abstract entity/abstraction/psychological feature/event	entity/physical entity/object/living thing/organism/person/adult/professional	lawyer FOR trial	☑
entity/abstract entity/abstraction/group/social group/organization	entity/physical entity/object/living thing/organism/person/worker	official FOR government	☑

lvii. Table showing new semantically annotated PWOP for R paraphrasing (FOR) towards artefact improvement

⌦ **O paraphrasing analysis:** Especially O (OF) PWOP seems a crowdedly multiple category, which happens to be data-hungry and includes lots of fact-intensive relations than those of the training set already sense-tagged. To back up this unsaid figure the Europarl corpus amounts to almost nearly 68.36% of instances showing the preposition OF as part of its encoding (Girju, 2009, p. 202). Thus by further analysing lexical hierarchies of incorrectly labelled instances,

O SR is able to offer extended heuristics and ways to specialise on O paraphrasing. Below semantically identified encoding has been added towards improvement:

Pruned T(Arg_1)	Pruned T(Arg_2)	SR	New?
entity/physical entity/thing/body of water	entity/physical entity/object/living thing	animal OF sea	☑
entity/abstract entity/abstraction/group/social group	entity/physical entity/object/whole/artifact/structure	cabinet OF university	☑
entity/abstract entity/abstraction/attribute/state/condition	entity/physical entity/object/living thing	organism OF disease	☑
entity/abstract entity/abstraction/attribute/state/condition	entity/abstract entity/abstraction/psychological feature/cognition	principle OF equivalence	☑
entity/abstract entity/abstraction/psychological feature/event	entity/abstract entity/abstraction/relation/magnitude relation	ratio OF vibration	☒
entity/physical entity/substance	entity/physical entity/process/natural process	source OF protein	
entity/abstract entity/abstraction/psychological feature/event/group action	entity/abstract entity/abstraction	god OF war	☒

lviii. Table showing new semantically annotated PWOP for O paraphrasing (OF) towards artefact improvement

⌦ **W paraphrasing analysis:** However, W (with) PWOP has been already mapped in the training set, incorrect paraphrasing suggests more W encoding precision can be achieved. According to "multiple meanings" categories major W encoding can be extended with WITH(Instrument), WITH(Accompaniment), WITH(Modifier), and WITH(Manner), just to name a few (Kidd, 2008). Further analysis over incorrectly labelled instances for W encoding has generated both, extra paraphrasing and new encoding. This way W heuristics will be divided into existing SRs and creation of new encoding, which is shown below:

Pruned T(Arg_1)	Pruned T(Arg_2)	SR	New?
entity/physical entity/substance/fuel	entity/physical entity/object/whole/artifact/instrumentality	lamp WITH kerosene	☑
entity/abstract entity/abstraction/attribute	entity/physical entity/object/whole/artifact/structure	hotel WITH luxury	☑
entity/physical entity/thing/body of water/stream	entity/physical entity/object/geological formation	valley WITH river	☑

entity/abstract entity/abstraction/attribute/state	entity/abstract entity/abstraction/psychological feature	food WITH convenience	☒
entity/physical entity/object/whole/artifact/instrumentality	entity/abstract entity/abstraction/communication/ auditory communication	concert WITH violin	☒

lix. Table showing new semantically annotated PWOP for W paraphrasing (WITH) towards artefact improvement

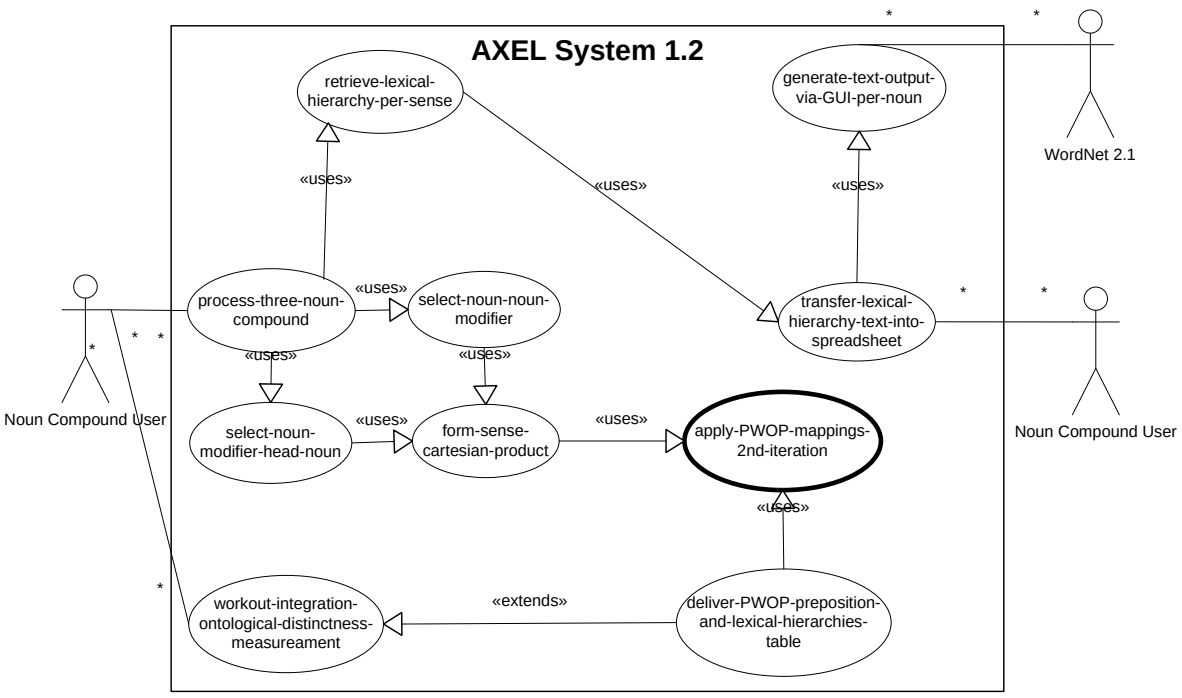
⌦ **T paraphrasing analysis:** Analysis shows that incorrectly paraphrased T (ABOUT) instances might help accuracy measures being increased. However, T paraphrasing will continue to work on extending earlier encoding as no new T category will be spawned. Further analysis has provided a handful of lexical hierarchy combinations for improved encoding, basically through the following rules:

Pruned T(Arg_1)	Pruned T(Arg_2)	SR	New?
entity/physical entity/process/phenomenon	entity/abstract entity/abstraction/communication	saga ABOUT family	☒
entity/abstract entity/abstraction	entity/abstract entity/abstraction/psychological feature/cognition/process	tale ABOUT horror	☒
entity/abstract entity/abstraction	entity/abstract entity/abstraction/psychological feature/cognition/content	science ABOUT life	☒
entity/physical entity/object/whole/artifact/structure/establishment	entity/abstract entity/abstraction/communication/ written communication	poem ABOUT prison	☒

lx. Table showing new semantically annotated PWOP for T paraphrasing (ABOUT) towards artefact improvement

The above Designer-aided annotation has already provided extra semantic paraphrasing in terms of fresh understanding of Lauer's lexical hierarchies. These extra paraphrasing changes will imply code reworks for coping with required extended functionality leading to a new version of the AXEL System.

To this end, variable definition will be altered in order to reflect these new rules, to process a second version of the Use-Case diagram xxvii, implying structural changes in the Use-Case "apply-PWOP-mappings" as follows:



lxi. Chart representing Use-Case diagram for modelling a second AXEL System version, showing internal system organisation with changes in the computational heuristics.

Essentially the redevelopment phase has engaged a new version for the AXEL System. For comparison Appendix C has documented semantic changes as encoded by programming sets of variable definitions.

This version has produced the 6th deliverable for this dissertation illustrating where Design and Development phases has been integrated throughout the second iteration.

Diagram lix shows the modifications over the Use-case diagram that deals with PWOP calculations that of “Apply-PWOP-mappings-2nd-Iteration”, which has been graphically represented with a bolder line in the chart.

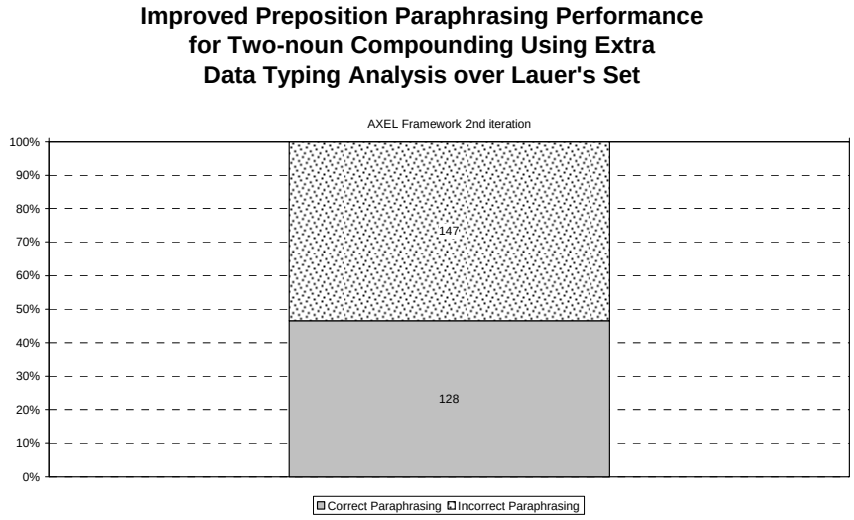
The next section will summarise the new experimental results for the second iteration of the new version of the AXEL System.

6.2.4. Two-noun Compound Results of the Second Iteration

This section reports on results obtained after programming a second version of the AXEL System. The testing schemas are unchanged, therefore leading to the reuse of the earlier Performance Measures from table liv.

Basically Lauer's set of 275 NNCs was evaluated under the new heuristics. The results obtained indicate a substantial improvement in accuracy by incorporation of freshly minted paraphrasing. A total 128 out of 275 noun compound instances were assigned the right preposition in the second iteration. Predicted instances therefore represent 46.55% accuracy.

Second iteration results are shown in the chart below, in which the solid sector of the chart depicts the correctly labelled instances.



lxii. Chart showing the performance by the supervised AXEL model on the Lauer's test set in the second iteration

This section has presented results obtained by the second iteration to measure the impact of sense-tagged specialisation on lexical hierarchy knowledge. Compared to the first iteration, results led an increase of 51 correctly labelled instances, some 60% improvement over earlier performance.

6.2.5. Experiments on the Three-noun Compound Sets

The testing of three-noun compounding involves a number of tasks that appear to have strongly interrelated influence to each other.

However in order to compare against to the Lauer's results, left-branching bracketing issues will be computed separate in order to asses the performance of the AXEL System, according to the 1st Performance Measure of the table liv.

Basically, the tasks for PWOP interpretation involve a set of two prepositions and corresponding calculations of the degree of association between noun constituents. Such measures will be discussed under the 1st and 2nd Performance Measure of table liv.

The NNNC test allows for double application of paraphrasing rules, so that the PWOP calculations can provide noun constituent interpretation, which involves two-preposition paraphrasing. NNNCs will therefore be measured against part of the original Lauer's set that includes all NNNC marked as left-branching.

The earlier supervised modelling remains as the means to testing NNNCs against the Lauer's set. However, the test set with sense-tagged annotation will be changed to include bracketing information. The AXEL System version 1.2 is to be used to account for freshly minted paraphrasing from the second iteration.

As already mentioned, 130 instances were selected, featuring left-branching semantic annotation under the category of NCs only. This is to say, nominalisations and any other CNs are not included, according to Lauer's random test from Grolier Encyclopaedia.

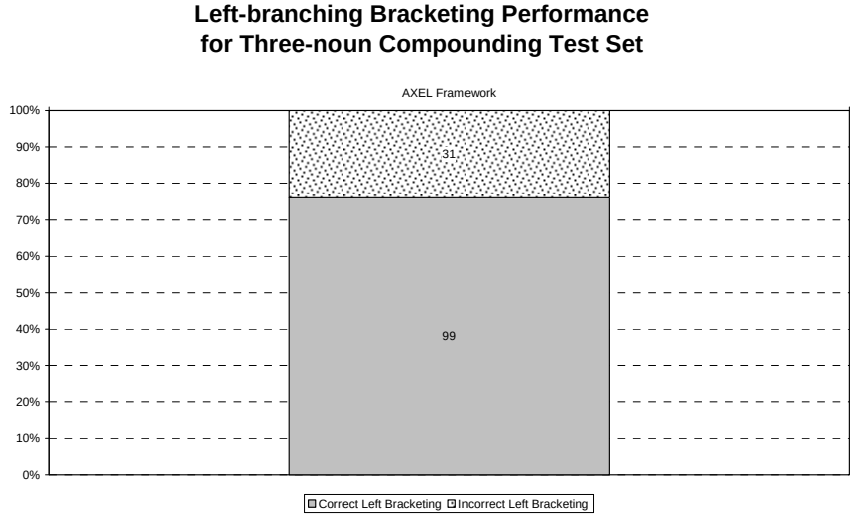
In the next section, the main results for the NNNC test will be presented and briefly analysed in order to reflect on the conclusions about the overall test.

6.2.6. Three-noun Compound Results

In this section, performance results from the AXEL System 1.2 will be obtained by testing Lauer's set of 130 NNNC instances. By doing so, the NNNC set is to undergo sense-tagged annotation processes to be assigned IOF as well as ODOF indexes, under the 2nd Performance Measure of table liv.

The results obtained by the AXEL System acknowledged that 99 out of 130 noun compounds were correctly labelled under the left-branching exercise. The accuracy for this part of the present evaluation represents 76.15%. The corresponding accuracy measure has been computed as the number of correctly labelled instances divided by the number of total instances in the NNNC test set.

Bracketing distribution is shown in the following chart, where the solid sector is meant to depict correctly labelled instances:



lxiii. Chart showing left-branching bracketing performance by the supervised AXEL model on the Lauer's NNNC test set

The detailed interpretation about the bracketing output will be reported and included in Appendix B. In the next section, a thorough discussion over the results will include both, bracketing accuracy and association performance.

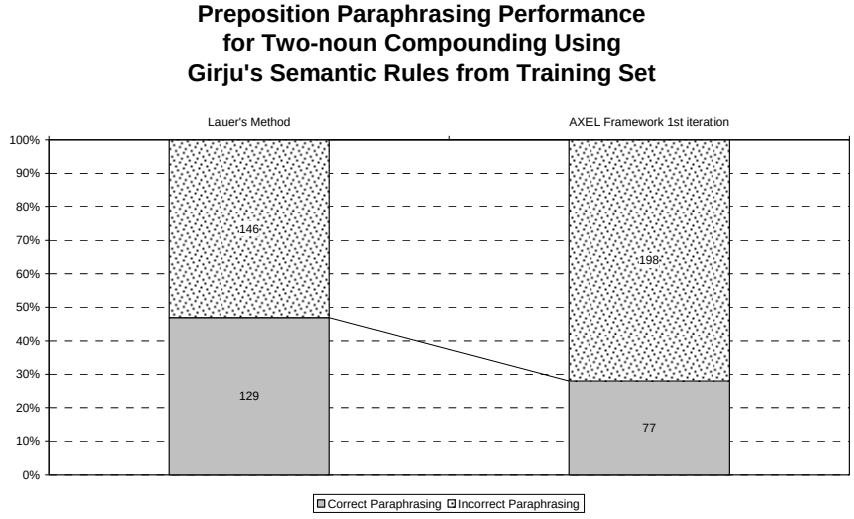
The next section deals with the comparison against the Lauer's work (1995a) to explain the accuracy in semantic annotation –NNC experiment- as well as the bracketing performance –NNNC experiment.

6.3. RESULTS COMPARISON

6.3.1. Previous Comparison on the Two-noun Compound Set

In the literature, Lauer (1995a) reported on his method obtained an accuracy of 40%, based on 400 NNC instances. However since this research has devised a sub collection leading to a smaller set of instances, the accuracy results need to be expressed over a 275-instance set. This leads to 46.91% Lauer's accuracy, instead.

Thus in the present test, Lauer obtained 46.91% of accuracy compared to that of the AXEL System of 28%. In the graph below both percentages are depicted by the solid sector:

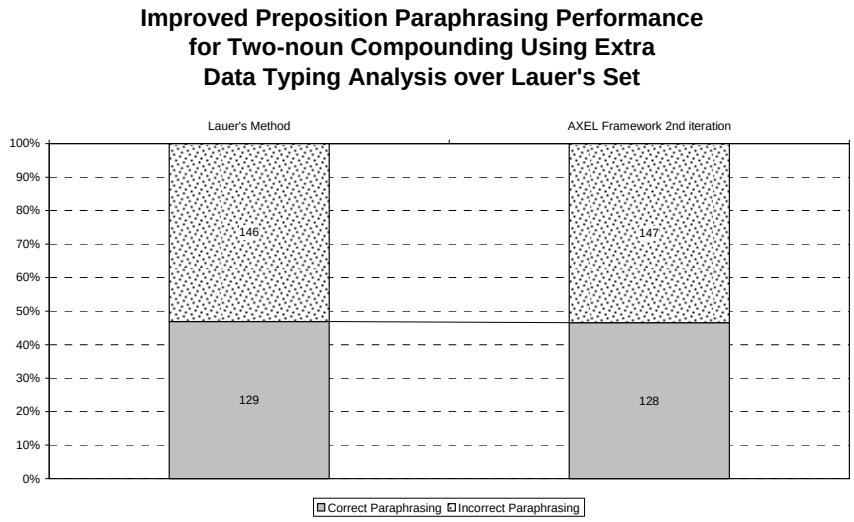


lxiv.Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNC test set for the first iteration

At a second iteration, this research performed replication of the NNC exercise under an extended set of rules for improved paraphrasing. The results showed an

improved accuracy percentage of 46.55%, which remains closely competitive to the Lauer's performance.

At the second iteration, Lauer obtained 46.91% of accuracy and the AXEL framework increased its accuracy measure up to 46.55%. In the following graph both percentages are depicted by the solid sector of the bars chart below:



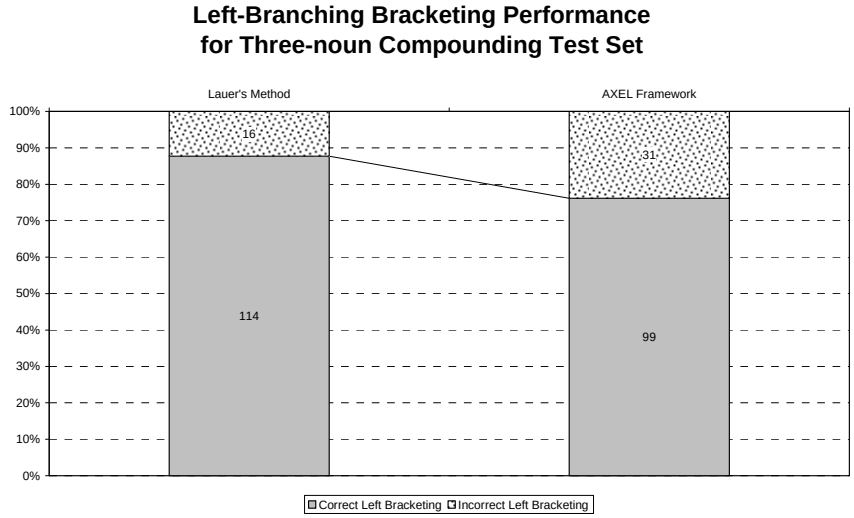
lxv. Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNC test set for the second iteration

From the charts above, it is apparent that the second iteration for the AXEL artefact nearly doubled its accuracy. Put it bluntly, from a methodological viewpoint a further semantic analysis has led to gains in accuracy to predict the correct paraphrasing between noun constituents.

6.3.2. Previous Comparison on the Three-noun Compound Set

This research has intended to compare the bracketing algorithms for the AXEL System regarding left-branching mechanisms only. It has been reported that Lauer's accuracy is 87.69% over the 130-instace set. Whereas the AXEL framework has obtained an accuracy of 76.15% on the same test set.

In the graph below both percentages describing bracketing issues were depicted by the solid sector:



lxvi.Chart showing performance comparison between the AXEL framework and the Lauer's method on the NNNC test set for bracketing accuracy

Experimental results have shown that the Lauer's method is superior in performance to the AXEL framework when it comes to classify left-branching instances over broader selection operation in Lauer's framework.

6.3.3. Lexical Results on the Three-noun Compound Set

This section presents the results regarding association of NC meanings to account for lexical ambiguity. These results have been studied in a separate section since they are not comparable to the Lauer's results, which address a different problem via corpus-based language learners.

The AXEL System along with the 2nd Performance Measure has provided a general viewpoint on association of meanings in NNNC structures within a corpus. The results below about association of meanings of NNNCs have allowed the acquisition of an unknown figure of the corpus, which characterises lexical ambiguity of the generative solution.

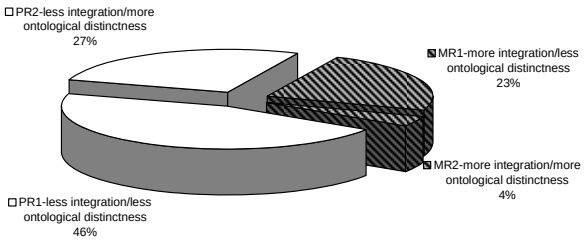
The results have been reported as a four-sector chart pie showing the distribution of the NNNCs in the corpus by ambiguous content. The 2nd Performance Measure allowed classifying a NC as AXEL, Monosemous, Polysemic or Extremely Polysemic, depending on the value pair of IOF and ODOF indexes.

The association figures have been computed as the number of NNNCs with complete PWOP information for both prepositions, divided by the number of total instances in the NNNC test set.

The darker sector in the graph below represents the AXEL NC distribution in the corpus, which is 23% over the 130-instace NNNC set. Next to the AXEL levels, the monosemous elements in the corpus can be seen to represent 4% of the total distribution. Overall non-polysemic NC distribution is therefore 27% in the corpus.

On the other hand, the white segments in the graphic show the polysemic NNNC distribution, which is of 27%; while, the extremely polysemic NNNC distribution amounts to 46%. Overall, 73% of the total NNNCs in the corpus are polysemic. The graphical patterns are shown below:

Ontological Distinctness and Integration Distribution for Three-noun Compounding Test Set per Region



lxvii. Chart showing distribution of ambiguous content according to integration (IOF) and ontological distinctness (ODOF)measures for the NNNC Lauer's corpus

The results above characterised the Lauer's NNNC corpus in a novel way by providing a number to account for lexical knowledge in terms ambiguity.

Remarkably, this number was unknown before the AXEL System has processed the lexical structure of the corpus. Roughly, new knowledge on lexical contents has allowed confirming that 7 out of 10 NCs in the corpus are polysemic. This is to say their components reveal a significant integration loss between their meanings, due to an increased number of paraphrasing interpretations.

Conversely, 3 out of 10 NCs are monosemous NCs, showing the maximum degree of integration that accounts for a total loss of autonomy. Even more due to ODOF numbers representing less autonomous lexical hierarchies, the statistics accounts for the maximum level of independence loss in the corpus. These characteristics were not available at a glimpse and only surfaced thanks to a computational approach to explaining associations between meanings in NNNC.

The next section will reflect on the results of this chapter and discusses the experimental observations by focusing on a comparison against to the Lauer's results, which are considered largely as benchmarked resources that any NC framework should be compared against.

6.3.4. Chapter Summary

This chapter advanced the logical links between development and evaluation as a concluding experience of Design. The second iteration for the AXEL system delivered a new solution in the solution space, virtually leaving the Design D unchanged. Instead, the fast-changing AXEL System carried out reengineering at the level of the semantics, having an impact on the rules that bound the prepositional paraphrasing. The result was a new artefact in the collection of artefacts of the RD methodology adopted in this work. Similarly, the set of Performance Measures was ultimately unchanged as well, as the supervised model accounted well for criteria success overall.

Regarding sense-annotated resources, the training set has been previously sense-tagged by designer intervention at a level of review-based reworks in Chapter 5,

due to time constraints and limited project scope for this PhD work (Blessing, 2009). However, this has not changed the supervised approach.

In order to prepare a confident test, this Evaluation phase had to make a number of adjustments in the data structures and algorithm formulation. The assumptions were largely explained and clarified throughout the phase to cast light on the results. For instance, the AXEL System involved partitioning the Lauer's exercise into two sets addressing NNC and NNNC structures. Despite Lauer's work (1995a) did not address a generative problem but a selection one, the 3rd Performance Measure allowed the AXEL generative problem to be expressed as a broader selection problem for NNC interpretation, so that the Lauer's comparison could be enabled.

Though the Lauer's set performance was superior in every department of the test, the present Design proved proactive regarding problem-solving, performance-improving, by achieving quick knowledge of the semantics of the lexical hierarchies. This promising approach nearly equalised the Lauer's performance for the NNC set at 46%.

Although the NNNC exercise unfolded assumptions that constrained the Lauer's set to half its original contents, the AXEL System responded promptly to an unplanned comparison to account for basic formulation of left-branching. Overall, the comparison allowed the major NC tasks of 1)the semantic interpretation of prepositions, 2)bracketing performance, and 3)the interpretation of association of meanings.

The most salient characteristic featured by the AXEL System was the delivery of computational metrics of a corpus to provide measures of integration and ontological distinctness between elements of a NC. This strategy provided weighing methods that represent a novel approach to accounting for automatic

acquisition of lexical information in a corpus. The results disclosed a fairly regular structure, otherwise largely hidden in the lexical organisation of the corpus.

In the next chapter, the final conclusions will be reflected and the experimental results discussed thoroughly, to conduct a critical review of what this dissertation achieved.

7. CONCLUSIONS

7.1. MAIN CONTRIBUTIONS

7.1.1. The Three Main Contributions

The research aim from Chapter 1 had envisaged a gap in the Dynamic Construal of Meaning framework relying on autonomy construals. To this end, this work argued the present researched framework –the Dynamic Construal of Meaning- can benefit from a computational approach. In order to explain this, this dissertation has highlighted three theoretical contributions to deal with computational tractability issues.

First, the present framework has advocated for a possible rapprochement between a linguistically formalised framework –the generative paradigm- and an linguistically experimental one –the cognitive paradigm-, helping reach a turning point into which software tools can inform linguists' theories.

Second, this dissertation has enriched the scope of a class of cognitive paradigms by implementing and outlining a computational template to interpret recursive three-noun compounds. Chiefly, this recursive approach has enabled the capacities of the AXEL System to generate meaningful paraphrasing, as opposed to a sense storage approach.

Third, the degree of association between noun constituents has been computationally analysed to account for ambiguity in three-noun compounds by ranking meanings according to the theoretical measures on integration -IOF- and Ontological Distinctness –ODOF- indexes.

Below, each of these three points will be discussed in more detail.

7.1.2. Informing Linguists' Theories via Software Tools

This dissertation has advocated for the adoption of linguistics studies to be informed by computational tools to disclose underlying complexities in text corpora, otherwise largely unaccounted for. Specifically the AXEL System delivered metrics to classify straightaway text corpus ambiguity. Results in Chapter 6 obtained a degree of association of 73% for the Lauer's set, which can be restated as approximately 7 out of 10 noun compounds in the corpus are polysemic. Essentially this figure was largely unknown. According to this theoretical contribution, such acquired lexical knowledge -73% distribution- will help human linguists reconsider a theory of ambiguity for noun compounds facilitating at a later stage –work foreseen as improvements ahead- selection of a unique paraphrasing towards major NLP applications.

The AXEL System is able to disclose hidden lexical patterns for 27% instances in the Lauer's set, labelling monosemous elements automatically. Without this software tool, this lexical knowledge would have been totally untraced. Intuitively the AXEL System has conveyed Design efforts to build automatic knowledge about unknown lexico-semantic information.

7.1.3. Tackling Limitations of Sense Enumerative Lexicons

This dissertation has enriched a cognitive paradigm to improve its generative capacity, by providing a means to control space/time computational parameters towards automatic lexical acquisition. Space/time elements of the computational system were handled as syntactic parameters –lexical hierarchies- which were queried from the knowledge base WordNet to illustrate the hard part of the work towards tractability. At this syntactic level of representation, the AXEL System was equipped with lexical hierarchies –the hard part of the Dynamic Construal of Meaning- that has been used to work out meanings "at the moment of use" through prepositional paraphrasing rules –the soft part of the Dynamic Construal of Meaning.

Computational tractability efforts helped outline a solution to deal with impoverished sense storage dictionaries (SEL's) by approaching optimisation of parameters in a computational space. This research argues that the AXEL System helped avoid enumerative approaches, as the AXEL System generated "at the moment of use" interpretations for noun compounds. The listings of all senses for each instance of the Lauer's set were previously unknown and untimely worked out on-line, to confirm the present contribution can tackle limitations of SELs which prefer sense storage over sense generation. Overall this limitation is a sad state of affairs for computational tractability.

7.1.4. Classifying Degrees of Association

This dissertation has handled figures and metrics to characterise noun compound ambiguity in terms of the degree of association of meaning. The inclusion of syntactic information has enabled understanding the polysemic nature of a three-noun compound, to gain awareness about ambiguous meanings in association "on-line". Hence the weighing methods of the AXEL System helped discriminate the polysemic content of a noun compound.

This dissertation developed a theoretical measure that does not operate with equal force over each member of a corpus, but works intelligently at four different levels: AXEL, Monosemous, Polysemic, and Extremely Polysemic NCs. This classification of discrepancy in meaning association builds a subsystem of ambiguity for three-noun compounds that works out "at the moment of use" meanings. These ranked meanings can assist at a later stage towards WSD via computational applications to determine unique paraphrasing for improving interpretation. Though the AXEL System does not engage in selecting the best underlying pair of prepositions, it paves the way to solving the selection problem of interpretation.

This theoretical index called the Degree of integration accounted for the most significant contribution of this dissertation as it allowed computational representation of lexical ambiguity in terms of two numbers: 1)IOF –number of

paraphrasing prepositions- and 2)ODOF –number of lexical hierarchies per paraphrasing preposition. These two numbers governs regions of meanings by grouping noun compounds into clusters with a similar lexical behaviour.

7.2. CONTRIBUTIONS TOWARDS ARTEFACTS

7.2.1. The Result Artefact: Summary

This dissertation has achieved overall results based on artefacts to supply computational advancements within the dynamic construal of meaning framework. The following paragraphs restate the main theoretical contributions from the last section, in terms of artefacts to contribute to a theory regarding ambiguity in three noun compounds:

⌦ **1st Result- The AXEL System contributed to a class of software tools that critically informs human linguistic theories regarding ambiguity in compounding:** The Result Artefact concluded theoretical ambiguity in noun compounding does not affect noun compound structures with equal force. It outlined heterogeneous methods for discrimination towards a theory of ambiguity about compounding leading to theoretical awareness of variable noun compound ambiguity.

⌦ **2nd Result- The AXEL System contributed to a class of computational templates that advocates for sense generation over sense storage:** The Result Artefact confirmed cognitive templates can be extended with computational features to sustain generative approaches of noun compound interpretation. The AXEL System enabled

computational elements to integrate a parametric subsystem of lexical hierarchies tackling SELs limitations.

⌦ **3rd Result- The AXEL System contributed to a class of theoretical ranking that provided weighing mechanisms to classify ambiguous noun compounds:** The AXEL system outlined a weighing method to discriminate interpretations according to degree of association working at four levels of ambiguity.

The table below summarises the three theoretical conclusions in the following Result Artefact, which constitutes the last Artefact according to diagram vi:

Result	Theoretical Summary
Informing Linguists' Theories via Software Tools	1st Result- The AXEL System contributed to a class of software tools that critically informs human linguistic theories regarding ambiguity in compounding:
Tackling Limitations of Sense Enumerative Lexicons	2nd Result- The AXEL System contributed to a class of computational templates that advocates for sense generation over sense storage
Classifying the Degree of Association of Meanings	3rd Result- The AXEL System contributed to a class of theoretical ranking that provided weighing mechanisms to classify ambiguous noun compounds

lxviii. Table showing measurable results throughout the Design Process as part of the Results Artefact

7.2.2. Future Considerations

This section aims to address a critical appraisal about an exceedingly difficult problem in NC interpretation from CL. A salient characteristic of the NC interpretation theory that surfaced in this research is its highly patchy nature, which rests upon a number of mathematical models of probabilistic vs. symbolic approaches, selection of right vs. left split in bracketing, formal theories of language vs. experimental frameworks of language, selection of the best type of paraphrasing in the symbolic paradigm, and disambiguation of the generated results.

Semantics is still a challenging question to answer in CL from a computational point of view. The prediction of ambiguous underlying relations between noun constituents is an overtly recalcitrant problem from a computational viewpoint. Despite positive results in the Literature, NC interpretation accuracy ranges from poor to fairly good, unsurprisingly leaving room for improvements and more critical evaluation about current solutions in the future.

NC interpretation is still pretty much in its infancy and the lack of paradigm shift to combine opposing frameworks has stopped the advent of a so-called turning point in CL. The collaboration of opposing theories is debatable as research has documented unsuccessful rapprochements. NC interpretation approaches hardly trust a rapprochement and sadly hold back the development of hybrid solutions in the field. Despite this, fresh insights on framework synergies to tackle a common problem of lexical ambiguity have started to emerge.

Counter-intuitively, publications in the field of NC interpretation have confirmed the progress of enthusiastic ideas, novel algorithms and freshly minted approaches, which have implemented cooperative solutions in the area of noun compound interpretation. Recently, despite a debatable rapprochement between frameworks, the future in NC interpretation has experienced a shift towards cooperation of theories, as this Literature Review showed.

This cooperative approach between opposing frameworks is not new whatsoever. Researchers are undertaking the challenging task of mingling frameworks, matching tenets, identifying common foundations from both areas -experimental theories and formal accounts of language- to strengthen a solution towards improving NC interpretation. The results have been hailed promising and looked bright in terms of proliferation of computational tools informing human theories of Linguistics, lexicographic resources capable of generating interpretations “on-line”

and weighing methods to acknowledge subsystems of ambiguity to affect noun compound structures at different levels.

This work understands, however, the area of the present research and its contributions in NC interpretation are ongoing, and therefore the AXEL System needs to be improved by dealing with the following modifications:

- **1st Improvement- Bracketing Process:** Future avenues to improvement research are to be opened with the inclusion of theory about bracketing. The AXEL System can improve by adopting other up-and-running paradigms, for instance the Lauer's algorithm. This would immediately spare the simplistic decision over left-branching straightaway. Instead, the AXEL System can integrate elements of the whole cycle of noun compounding interpretation, which might result in a more robust theoretical implementation. This would allow predicting the semantics of the complementary class of right-branching NCs of the English lexicon.

- **2nd Improvement- Contextual Constraints:** Introduction of context and systems of countervailing forces would be extremely useful in reducing the number of productive rules for a NC. Context inclusion will help rule out some generated output of the AXEL System. This way, the narrowed down listings of interpretation might transform a generative problem into a selection problem, contributing towards WSD.

- **3rd Improvement- Exhaustive Data Training:** The training of a set of sense-tagged elements is a crucial activity in supervised approaches, having the impact of producing better annotation, and therefore better theories. An

improvement to the AXEL system will look to the complete revision of the training sets to annotate whole meaningful rules to enable better paraphrasing across the corpus.

8. REFERENCES

8.1. BOOKS, JOURNALS, CONFERENCES, AND WEBSITES

8.1.1. Referenced Literature

[1] Abdullah, N. and Frost, A.F. (2007). **"Rethinking the Semantics of Complex Nominals".** Lecture Notes in Computer Science, Volume 4509/2007, pages 502-513. Springer. Berlin, Heidelberg. DOI 10.1007/978-3-540-72665-4. ISBN 978-3-540-72664-7

[2] Agirre, E. and Edmonds, P. (eds.) (2006). **"Word Sense Disambiguation: Algorithms and Applications".** Text, Speech and Language Technology, Volume 33. Springer

[3] Arens, Y., et al. (1987). **"Phrasal Analysis of Long Noun Sequences".** Proceedings of the 25th Annual Meeting of the Association fro Computational Linguistics, Pages:637-655. Stanford, California. USA

[4] Baldwin, T. and Tanaka, T. (2004). **"Translation by Machine of Complex Nominals: Getting it Right".** Proceedings of the Workshop on Multiword Expressions: Integrating Processing table of contents, Pages:24-31. Barcelona. Spain

[5] Baldwin, T., et. al. (2009). **"Prepositions in Application: A Survey and Introduction to the Special Issues".** Computational Linguistics. Vol. 35, No. 2, Pages:119-149 (June 2009)

[6] Barker, K (1998a). **"A trainable Bracketer for Noun Modifiers".** Lecture notes in computer science. AI '98 : Advances In Artificial Intelligence (1998). Vancouver. USA. ISSN 0302-9743

[7] Barker, K. and Szpakowicz, S. (1998b). **"Semi-Automatic Recognition of Noun Modifier Relationships".** Proceedings of COLING-ACL98. Montreal, Quebec (1998). Canada

[8] Barret, L., et. al. (2001). **"Interpretation of Compound Nominals Using WordNet".** Lecture Notes In Computer Science, Vol. 2004, Pages:169-181. Proceedings of the Second International Conference on Computational Linguistics and Intelligent Text Processing table of contents (2001). ISBN:3-540-41687-0

[9] Bauer, L. (2006). **"Compound".** Encyclopaedia of Language and Linguistics, Second Edition. 14-Volume Set, Pages:719-725. Elsevier. ISBN: 978-0-08-044854-1

[10] Bayazit, N. (1993). **"Designing: Design Knowledge: Design Research: Related Sciences".** In: De Vries, M.J., et. al. (eds.) **"**Design Methodology and Relationships with Science". NATO ASI Series, Vol. 71, Series D: Behavioral and Social Sciences, Pages:121-136. Kluwer Academic Publishers. Eindhoven, The Netherlands

[11] Blessing, L.T.M. and Chakrabarti, A. (2009). **"DRM, a Design Research Methodology".** Springer. ISBN: 978-1-84882-586-4

[12] Blessing, L.T.M., et al. (1998). **"An Overview of Descriptive Studies in Relation to a General Design Research Methodology".** In: Frankerberger, E., et. al. (eds.). "Designers: The Key to Successful Product Development", Pages:42-56. Springer. London. UK. ISBN:1852330317

[13] Caudal, P. (1998). **"Using Complex Lexical Types to Model the Polysemy of Collective Nouns within the Generative Lexicon".** Database and Expert Systems Applications, 1998. Proceedings. Ninth International Workshop on. DEXA Workshop, Pages:154-159. Paris VII University. France

[14] Choi, M., et. al (2007). **"A Model on the Processing of Noun-Noun Conceptual Combination and Its Verification".** ICNC: Proceedings of the Third International Conference on Natural Computation, Volume 05, Pages:516-520. IEEE Computer Society Washington, DC. USA. ISBN:0-7695-2875-9

[15] Copestake, A. (2001). **"The Semi-Generative Lexicon: Limits on Lexical Productivity".** Proceedings of the First International Workshop on Generative Approaches to the Lexicon. Geneva

[16] Copestake, A. and Briscoe, T. (1991). **"Lexical Operations in a Unification Based Framework (ACQUILEX WP NO. 21)"**. Proceedings of ACL SIGLEX Workshop on Lexical Semantics and Knowledge Representation, Pages: 88-101. Berkeley, California, USA

[17] Costello, F. and Keane, M.T. (1996). **"Polysemy in Conceptual Combination: Testing the Constraint Theory of Combination"**. Dublin, Trinity College Dublin, Department of Computer Science, TCD-CS-96-19, 1996, Pages:1-6

[18] Costello, F. J. (2002). **"Investigating Creative Language: People's Choice of Words in the Production of Noun-Noun Compounds".** In Gray, W. D. & Schunn, C. D. (eds.) Twenty-Fourth Annual Conference of the Cognitive Science Society, Pages:232-237. Lawrence Erlbaum Associates. Mahwah, NJ. USA

[19] Costello, F. J., et. al. (2006). **"Using WordNet to Automatically Deduce Relations between Words in Noun-Noun Compounds".** Proceedings of the COLING/ACL on Main conference poster sessions, Pages:160 - 167. Sydney, Australia

[20] Cowie, A. (2006). **"Lexicology".** Encyclopaedia of Language and Linguistics, Second Edition. 14-Volume Set, Pages:128-133. ISBN: 978-0-08-044854-1. Elsevier

[21] Croft, W. and Cruse, D.A. (2004). **"Cognitive Linguistics".** Cambridge University Press. UK.

[22] Cruse, D.A. (1993). **"Towards a Theory of Polysemy".** AAAI Technical Report SS-93-02

[23] Cruse, D.A. (1995). **"Polysemy and Related Phenomena from a Cognitive Linguistic Viewpoint".** In: Saint-Dizier, P. (Eds.). "Computational Lexical Semantics". ISBN-13:9780521023207. ISBN-10:0521023203

[24] Cruse, D.A. (2001). **"Microsenses, Default Specificity and the Semantics-Pragmatics Boundary".** Axiomathes, Volume 12, Numbers 1-2 / March, 2001. DOI: 10.1023/A:1012741501889

[25] Dasgupta, S. (1992). **"Herbert Simon's 'Science of Design': Two Decades Later".** Intelligent Systems Engineering, 1992, First International Conference on (Conf. Publ. No. 360), Pages:171-178. Edinburgh, UK

[26] Devereux, B. and Costello, F. (2005). **"Investigating the Relations used in Conceptual Combination".** Artificial Intelligence Review. Volume 24, Issue 3-4 (November 2005), Pages:489-515. Kluwer Academic Publishers . Norwell, MA. USA. ISSN:0269-2821

[27] Downing, P. (1977). **"On the Creation and Use of English Compound Nouns".** Language, Vol. 53, No. 4 (Dec., 1977), Pages:810-842. Linguistic Society of America

[28] Fabb, N. (1998). **"Compounding".** In: Spencer A., and Zwicky, A. M. (eds.). "The handbook of morphology", Pages:66-83. Blackwell Publishers. Malden, Massachusetts. USA

[29] Fellbaum, C. (1998). **"WordNet an Electronic Lexical Database".** MIT Press. Cambridge, Massachusetts, London, England

[30] Finin, T.W. (1980). **"The Semantic Interpretation of Nominal Compounds".** Proceedings of First Annual National Conf. on Artificial Intelligence (AAAI-80)

[31] Gagné, C.L. (2002). **"The Competition-among-relations-in-nominals Theory of Conceptual Combination: Implications for Stimulus Class Formation and Class Expansion".** Journal of The Experimental Analysis of Behaviour, 78, number 3, Pages:551-565

[32] Geeraerts, D. (2006). **"Words and Other Wonders: Papers on Lexical and Semantic Topics".** Mouton de Gruyter. ISBN: 978-3-11-021912-8

[33] Girju, R. (2009a). **"The Syntax and Semantics of Prepositions in the Task of Automatic Interpretation of Nominal Phrases and Compounds: A Cross-Linguistic Study".** Computational Linguistics. Vol. 35, No. 2, Pages:151-184

[34] Girju, R., et. al. (2005). **"On the Semantics of Noun Compounds".** Computer Speech and Language, Volume 19, Issue 4, (2005), Pages:479-496. Special issue on Multiword Expression. Elsevier. DOI:10.1016/j.csl.2005.02.006

[35] Girju, R., et. al. (2009b). **"Classification of Semantic Relations between Nominals".** Language Resources and Evaluation, 43, Pages:105-121. DOI:10.1007/s10579-009-9083-2

[36] Isabelle, P. (1984). **"Another Look at Nominal Compounds".** Annual Meeting of the ACL archive

[37] Johnston, M. and Busa, F. (1996). **"Qualia Structure and the Compositional Interpretation of Compounds".** Proceedings of the ACL SIGLEX workshop on breadth and depth of semantic lexicons.

[38] Johnston, M., et. al. (1995). **"The Acquisition and Interpretation of Complex Nominals".** Working Notes of AAAI Spring Symposium on the Representation and Acquisition of Lexical Knowledge. AAAI

[39] Kidd, E., Cameron-Faulkner, T. (2008). **"The Acquisition of the Multiple Senses of With".** Linguistics, 2008, vol. 46, no1, pp. 33-61. De Gruyter, Berlin, Germany. ISSN 0024-3949

[40] Kilgarriff, A. (2001). **"Generative Lexicon Meets Corpus Data: The Case of Non-Standard Word Uses".** In: Bouillon, P. and Busa, F (eds). "The Language of Word Meaning", Pages:312-328. Cambridge University Press. ISBN-13: 9780521780483 | ISBN-10: 0521780489

[41] Kim, S. N. and Baldwin, T. (2005). **"Automatic Interpretation of Noun Compounds Using WordNet Similarity".** Proceedings of Second International Joint Conference on Natural Language Processing. Jeju Island, South Korea

[42] Kim, S. N. and Baldwin, T. (2007). **"Disambiguating Noun Compounds".** Proceedings of the 22nd AAAI Conference on Artificial Intelligence, AAAI-07

[43] Kim, S.N. and Baldwin, T. (2008). **"Standardised Evaluation of English Noun Compound Interpretation".** Proceeding of the LREC workshop: Towards a Shared Task of Multiword Expressions (MWE 2008), pages:39-42. Marrakesh, Morocco

[44] Kobayashi, M. and Takeda, K. (2000**). "Information Retrieval on the Web".** ACM Computing Surveys, Vol. 32, No. 2

[45] Krovetz, R. (1997). **"Homonymy and Polysemy in Information Retrieval".** European Chapter Meeting of the ACL, Proceedings of the eighth conference on European chapter of the Association for Computational Linguistics, Pages:72 - 79. Madrid. Spain

[46] Lakoff, G. (1987). **"Women, Fire, and Dangerous Things".** University Of Chicago Press. USA

[47] Lapata, M. (2000). **"The Automatic Interpretation of Nominalisations".** Proceedings of the Seventeenth National Conference on Artificial Intelligence and Twelfth Conference on Innovative Applications of Artificial Intelligences. Austin, Texas. USA

[48] Lapata, M. (2002). **"The Disambiguation of Nominalisations".** Computational Linguistics, Volume 28, Issue 3, Pages:357-388. ISSN:0891-2017

[49] Lauer, M. (1995a). **"Corpus Statistics Meet the Noun Compound: Some Empirical Results".** Annual Meeting of the ACL archive. Proceedings of the 33rd annual meeting on Association for Computational Linguistics, Pages:47-54. Association for Computational Linguistics. Morristown, NJ, USA

[50] Lauer, M. (1995b). **"Designing Statistical Language Learners: Experiments on Noun Compounds".** PhD Thesis. Department of Computing, Macquarie University, NSW 2109, Australia.

[51] Lynott, D. and Keane, M. (2004b). **"The Role of Knowledge Support in Creating Noun-Noun Compounds".** CogSci 2003: 25th Annual Meeting of the Cognitive Science Society

[52] Lynott, D., et. al. (2004a). **"Conceptual Combination with PUNC".** Artificial Intelligence Review 21, Pages:353-374. Kluwer Academic Publishers. The Netherlands

[53] Maguire, P., et. al (2007). **"The Role of Experience in the Interpretation of Noun-Noun Combinations".** Artificial Intelligence Review, Issue Volume 25, Numbers 1-2, Pages:139-160. Springer. Netherlands. ISSN 0269-2821. DOI 10.1007/s10462-007-9020-y

[54] Maguire, P., et. al (2010). **"The Influence of Interactional Semantic Patterns on the Interpretation of Noun-Noun Compounds".** Journal of Experimental Psychology: Learning, Memory, and Cognition, v36, n2, Pages:288-297, Mar 2010. American Psychological Association. Washington, DC. USA. ISSN ISSN-0278-7393

[55] Malmkjaer, K. (1991). **"The Linguistics Encyclopaedia".** Routledge. NY, USA.

[56] March, S.T. and Smith, G. F. (1995). **"Design and Natural Science Research on Information Technology".** Volume 15, Issue 4 (December 1995). Special issue on WITS '92, Pages:251-266. Elsevier. Amsterdam, The Netherlands. The Netherlands. ISSN:0167-9236

[57] McDonald, D.D. and Busa, F. (1994). **"On the Creative Use of Language: the Form of Lexical Resources".** Proc. of 7th International Workshop on Natural Language Generation. Kennebunkport, Maine.

[58] Miller, G. A. and Fellbaum, C. (2007). **"WordNet then and now".** Language Resources and Evaluation, Volume 41, Number 2, pages:209-214. DOI: 10.1007/s10579-007-9044-6

[59] Miller, G. A., (1995). **"WordNet: a Lexical Database for English".** Communications of the ACM, Volume 38, Issue 11 (November 1995), Pages:39-41. ACM New York, NY. USA. ISSN:0001-0782

[60] Moldovan, D. and Novischi, A. (2004a). **"Word Sense Disambiguation of WordNet Glosses".** Computer Speech and Language 18 (2004) 301-317. Elsevier

[61] Moldovan, D., et. al. (2004b). **"Models for the Semantic Classification of Noun Phrases".** Human Language Technology Conference, Proceedings of the HLT-NAACL Workshop on Computational Lexical Semantics, Pages:60-67. Association for Computational Linguistics. Morristown, NJ. USA

[62] Nakov, P. and Hearst, M. (2005). **"Search Engine Statistics beyond the n-gram: Application to Noun Compound Bracketing".** Association for Computational Linguistics. Proceedings of CoNLL '05, Pages:17-24

[63] Nakov, P. (2008a). **"Paraphrasing Verbs for Noun Compound Interpretation".** In Proceedings of the LREC'08 Workshop: Towards a Shared Task for Multiword Expressions (MWE'08). Marrakech, Morocco

[64] Nakov, P. (2008b). **"Noun Compound Interpretation Using Paraphrasing Verbs: Feasibility Study".** Lecture Notes In Artificial Intelligence; Vol. 525, pages:103-117. Proceedings of the 13th international conference on Artificial Intelligence: Methodology, Systems, and Applications. Marrakech, Morocco. Varna, Bulgaria (2008). ISBN:978-3-540-85775-4

[65] Nakov, P. and Hearst, M. (2006). **"Using Verbs to Characterize Noun-Noun Relations".** Artificial Intelligence: Proceedings 2006, Methodology, Systems, and Applications, 12th International Conference, AIMSA 2006, Pages:233-244. Varna. Bulgaria

[66] Navigli, R. (2009). **"Word Sense Disambiguation: A Survey".** ACM Comput. Surv., Volume 41, No. 2, Pages:1-69. ISSN:0360-0300

[67] Nicholson, J. and Baldwin, T. (2005). **"Statistical Interpretation of Compound Nominalisations".** Proceeding of the Australasian Language Technology Workshop 2005, Pages:152-159. Sydney, Australia

[68] Nicholson, J. and Baldwin, T. (2008). **"Interpreting Compound Nominalisations".** Proceeding of the LREC workshop: Towards a Shared Task of Multiword Expressions (MWE 2008), pages:43-45. Marrakesh, Morocco

[69] Nunamaker, J.F. Jr., et. al. (1990). **"Systems Development in Information Systems Research".** Journal of Management Information Systems, Volume 7, Issue 3 (Winter1990/91), Pages:89 - 106. M. E. Sharpe, Inc. Armonk, NY. USA. ISSN:0742-1222

[70] Onysko, A. (2009). **"On the Semantic Structure of English and German Compounds: Head-Frame Internal Specifier Selection as a Principle of Compound Formation".** SALC: Second Conference of the Swedish Association for Language and Cognition

[71] Priestley, M (2000). **"Practical Object-Oriented Design with UML".** McGraw-Hill Publishing Company. England. UK

[72] Princeton University (2010). **"Download WordNet Packages".** 18 January, 2010. URL:http://wordnet.princeton.edu/wordnet/download/

[73] Pustejovsky, J. (1991). **"The Generative Lexicon".** Association for Computational Linguistics. Computational Linguistics, Volume 17, Issue 4 (December 1991), Pages:409 - 441. ISSN:0891-2017

[74] Pustejovsky, J. (1995). **"The Generative Lexicon".** MIT Press. Cambridge, MA. USA

[75] Pustejovsky, J. (1998). **"The Semantics of Lexical Underspecification".** Folia Linguistica, Volume 32, No. 3-4, Pages:323-347

[76] Pustejovsky, J. (2006). **"Lexical Semantics: Overview".** Encyclopaedia of Language and Linguistics, Second Edition. 14-Volume Set, Pages:98-105. ISBN: 978-0-08-044854-1. Elsevier

[77] Pustejovsky, J. and Anick, P.A. (1988). **"On the Semantic Interpretation of Nominals".** Proc. COLIN88

[78] Pustejovsky, J. and Boguraev, B. (1993b). **"Lexical Knowledge Representation and Natural Language Processing".** Artificial Intelligence, 63, Pages:193-223. Elsevier

[79] Pustejovsky, J., et. al. (1992). **"The Acquisition of Lexical Semantic Knowledge from Large Corpora".** Speech and Natural Language: Proceedings of a Workshop Held at Harriman, New York, February 23-26, 1992. New York, NY. USA.

[80] Pustejovsky, J., et. al. (1993a). **"Lexical Semantic Techniques for Corpus Analysis".** Computational Linguistics, Volume 19, Issue 2, Pages:331-358. MIT Press. Cambridge, MA, USA

[81] Ravin, Y. and Leacock, C. (Eds.), (2000). **"Polysemy. Theoretical and Computational Approaches".** Oxford University Press, Oxford. UK

[82] Resnik, P. (1995). **"Disambiguating Noun Groupings with Respect to WordNet Senses".** Proceedings of the 3rd Workshop on Very Large Corpora. MIT

[83] Rosario, B. and Hearst, M (2001). **"Classifying the Semantic Relations in Noun Compounds via a Domain-Specific Lexical Hierarchy".** Proceedings of 2001 Conference on Empirical Methods in Natural Language Processing, Pittsburgh, PA (EMNLP 2001)

[84] Sanfilippo, A., et. al. (1994). **"Virtual polysemy".** International Conference on Computational Linguistics. Proceedings of the 15th conference on Computational linguistics, Volume 2, Pages:696-700. Association for Computational Linguistics Morristown. NJ. USA

[85] Saunders, M, et. al. (2003). **"Research Methods for Business Students".** Prentice Hall, Financial Times. Harlow, England. UK

[86] Shepherd, S. J. (2007). **"Concepts and Architectures for Next-generation Information Search Engines".** International Journal of Information Management 27 (2007), Pages:3-8. Elsevier

[87] Smith, E. E. and Osherson, D. N. (1984). **"Conceptual Combination with Prototype Concepts".** Cognitive Science, Volume 8, Issue 4, October-December 1984, Pages:337-361. Elsevier

[88] Smith, G. W. (1991). **"Computers and Human Language".** Oxford University Press (1991). New York, USA. ISBN:0195062825

[89] Sproat, R.W. and Liberman, M. Y. (1987**). "Toward Treating English Nominals Correctly".** Annual Meeting of the ACL archive, Proceedings of the 25th annual meeting on Association for Computational Linguistics, Pages:140-146. Stanford, California. USA

[90] Stokoe, C. (2005). **"Differentiating Homonymy and Polysemy in Information Retrieval".** Proceedings of Human Language Technology Conference and Conference on Empirical Methods in Natural Language. Processing (HLT/EMNLP), Pages:403-410. Vancouver. USA

[91] Taylor, J. R. (2003). **"Polysemy's Paradoxes".** Language Sciences, Volume 25, Issue 6, November 2003, Pages:637-655. Elsevier

[92] Tribble, A. and Fahlman, S.E. (2006). **"Resolving Noun Compounds with Multi-Use Domain Knowledge".** Proceedings of the Nineteenth International Florida Artificial Intelligence Research Society Conference. Melbourne Bseach, Florida. USA

[93] Vadas, D. and Curran, J.R. (2007). **"Large-Scale Supervised Models for Noun Phrase Bracketing".** Proceedings of the 10th Conference of the Pacific Association for Computational Linguistics, pages 104-112, PACLING 2007. Australia

[94] Vaishnavi, V. and Kuechler, W. (2004). **"Design Research in Information Systems"** January 20, 2004, last updated August 16, 2009. URL:http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=279

[95] Vossen, P. (1998). **"EuroWordNet: A Multilingual Database with Lexical Semantic Networks".** Computational Linguistics, Volume 25, Reprinted from Computers and the Humanities, 32(2-3), (1998). Kluwer Academic Publishers. ISBN 0-7923-5295-5

[96] Weiskopf, D.A. (2007). **"Compound Nominals, Context, and Compositionality".** Journal Synthese, Issue Volume 156, Number, Pages:161-204. ISSN:0039-7857. Humanities, Social Sciences and Law. SpringerLink

[97] Wilkenfeld, M.J. and Ward, T.B. (2001). **"Similarity and Emergence in Conceptual Combination".** Journal of Memory and Language, Volume 45, Number 1, July 2001, Pages:21-38 (18). Academic Press

[98] Wilks, Y. (2006). **"Computational Linguistics: History".** Encyclopaedia of Language and Linguistics, Second Edition. 14-Volume Set, Pages:128-133. ISBN: 978-0-08-044854-1. Elsevier

[99] Willems, K. (2006). **"Logical Polysemy and Variable Verb Valency".** Language Sciences, Volume 28, Issue 6, (2006), Pages:580-603. Elsevier. DOI:10.1016/j.langsci.2005.10.004

[100] Winter, R. (2008). **"Design Science Research in Europe".** European Journal of Information Systems (2008) 17, Pages:470-475. DOI:10.1057/ejis.2008.44

[101] Wisniewski, E.J. and Love, B.C. (1998). **"Relations versus Properties in Conceptual Combination".** Journal of Memory and Language, Volume 38, Number 2, February 1998, Pages:177-202 (26). Academic Press

[102] Zlatev, J., et. al. (2010). **"Noun-noun Compounds for Fictive Food Products: Experimenting in the Borderzone of Semantics and Pragmatics".** Journal of Pragmatics, Volume 42, Issue 10, October 2010, Pages:2799-2813. Elsevier. ISBN/ISSN/Other ISSN: 0378-2166

9. APPENDIXES

9.1. SUPPORTING MATERIAL

9.1.1. Appendix A: Two-noun Compound Results

For comparison, this appendix shows all transcribed NNCs that were included in the NNC test along with the results for preposition prediction from the AXEL System, which was encoded as follows: OF (O), FOR (R), WITH (W), IN (I), ON (A), AT (A), ABOUT (T), FROM (F), BY (Y), IS-A-HYPERNYM (B). The noun category for nominalisations and errors were excluded. Duplicate records were not processed either. The Lauer's Copula B NC was represented by encoding SR Is-a-hypernym in the Girju's table lix (2009a). The remainder of the category NNC contained the vast majority of NCs which were used in the test to overall account for a 46% accuracy.

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
CONCERT	MUSIC	CONCERT MUSIC	R		A	NNC
FRONTIER	LIFE	FRONTIER LIFE	N		A	NNC
CROSSROADS	VILLAGE	CROSSROADS VILLAGE	O		A	NNC
PEST	SPECIES	PEST SPECIES	B		B	is-a-hypernym
CIVILIAN	POPULATION	CIVILIAN POPULATION	B		B	is-a-hypernym
OXYGEN	ATOM	OXYGEN ATOM	B		B	is-a-hypernym
ARAB	ORIGIN	ARAB ORIGIN	B		B	is-a-hypernym
HYDROGEN	ATOM	HYDROGEN ATOM	B		B	is-a-hypernym
ALPHA	PARTICLE	ALPHA PARTICLE	B		B	is-a-hypernym
BUDDHIST	LAITY	BUDDHIST LAITY	B		B	is-a-hypernym
PATRON	GODDESS	PATRON GODDESS	B		B	is-a-hypernym
FOOD	RESOURCE	FOOD RESOURCE	B		B	is-a-hypernym
ANTENNA	ROD	ANTENNA ROD	B		B	is-a-hypernym
MOUNTAIN	BARRIER	MOUNTAIN BARRIER	B		B	is-a-hypernym
VORTEX	ATOM	VORTEX ATOM	B		B	is-a-hypernym
TENOR	TROMBONE	TENOR TROMBONE	B		B	is-a-hypernym
PUPPET	GOVERNMENT	PUPPET GOVERNMENT	B		B	is-a-hypernym
PERTUSSIS	BACTERIA	PERTUSSIS BACTERIA	B		B	is-a-hypernym
SOPHOMORE	YEAR	SOPHOMORE YEAR	B		B	is-a-hypernym
PUPPET	REGIMEN	PUPPET REGIMEN	B		B	is-a-hypernym
GOVERNMENT	PATRONAGE	GOVERNMENT PATRONAGE	O		F	NNC
WAR	CAPTIVE	WAR CAPTIVE	A		F	NNC
BACKWOODS	PROTAGONIST	BACKWOODS PROTAGONIST	I		F	NNC
SEPARATION	NEGATIVE	SEPARATION NEGATIVE	O		F	NNC
SEA	URCHIN	SEA URCHIN	O		F	NNC
COMPUTATION	SKILL	COMPUTATION SKILL	R		I	NNC
BUSINESS	INVESTMENT	BUSINESS INVESTMENT	I		I	NNC
BUSINESS	APPLICATION	BUSINESS APPLICATION	O		I	NNC
PHOTOGRAPHY	MOVEMENT	PHOTOGRAPHY MOVEMENT	R		I	NNC
COALITION	CABINET	COALITION CABINET	F		I	NNC
JESUIT	ORIGIN	JESUIT ORIGIN	O		I	NNC
HARDWARE	BUSINESS	HARDWARE BUSINESS	W		I	NNC
LANGUAGE	LITERATURE	LANGUAGE LITERATURE	T		I	NNC
WAR	CRIME	WAR CRIME	A		I	NNC
COALITION	GOVERNMENT	COALITION GOVERNMENT	I		I	NNC
EMERGENCY	DETENTION	EMERGENCY DETENTION	R		I	NNC
OPPOSITION	COALITION	OPPOSITION COALITION	W		I	NNC
JANUARY	TEMPERATURE	JANUARY TEMPERATURE	I		I	NNC
HOUSEHOLD	REFRIGERATION	HOUSEHOLD REFRIGERATION	I		I	NNC

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
CHILDHOOD	SEXUALITY	CHILDHOOD SEXUALITY	I		I	NNC
PERCENTAGE	COMPOSITION	PERCENTAGE COMPOSITION	O		I	NNC
ALTITUDE	RECONNAISSANCE	ALTITUDE RECONNAISSANCE	F		I	NNC
LAB	PERIOD	LAB PERIOD	R		I	NNC
SANSKRIT	TEXT	SANSKRIT TEXT	F		I	NNC
INDUSTRY	REVENUE	INDUSTRY REVENUE	F		I	NNC
LABORATORY	APPLICATION	LABORATORY APPLICATION	I		I	NNC
CENSUS	POPULATION	CENSUS POPULATION	F		N	NNC
TELEVISION	NEWSCASTER	TELEVISION NEWSCASTER	N		N	NNC
CITY	LEGISLATURE	CITY LEGISLATURE	I		O	NNC
DISEASE	ORGANISM	DISEASE ORGANISM	F		O	NNC
ANTIBIOTIC	REGIMEN	ANTIBIOTIC REGIMEN	O		O	NNC
ANATOMY	PROFESSOR	ANATOMY PROFESSOR	O		O	NNC
SECURITY	PACT	SECURITY PACT	O		O	NNC
FAMILY	MEMBER	FAMILY MEMBER	O		O	NNC
PLUTONIUM	THEFT	PLUTONIUM THEFT	O		O	NNC
UNION	LEADER	UNION LEADER	F		O	NNC
CLIMATE	PATTERN	CLIMATE PATTERN	N		O	NNC
CERAMICS	PRODUCT	CERAMICS PRODUCT	O		O	NNC
APPLICATION	AREA	APPLICATION AREA	R		O	NNC
BUSINESS	HOLDING	BUSINESS HOLDING	I		O	NNC
PIGMENT	GRANULE	PIGMENT GRANULE	I		O	NNC
POTTERY	VESSEL	POTTERY VESSEL	N		O	NNC
POPULATION	DENSITY	POPULATION DENSITY	O		O	NNC
BUSINESS	SECTOR	BUSINESS SECTOR	O		O	NNC
CAR	ODOR	CAR ODOR	O		O	NNC
WORLD	COMMUNITY	WORLD COMMUNITY	I		O	NNC
POPULATION	EXPLOSION	POPULATION EXPLOSION	O		O	NNC
HARDWARE	TECHNOLOGY	HARDWARE TECHNOLOGY	I		O	NNC
DRAINAGE	BASIN	DRAINAGE BASIN	W		O	NNC
HEATH	FAMILY	HEATH FAMILY	O		O	NNC
WAR	GOD	WAR GOD	O		O	NNC
MAJORITY	LEADER	MAJORITY LEADER	F		O	NNC
GOVERNMENT	POLICY	GOVERNMENT POLICY	O		O	NNC
OCEAN	BASIN	OCEAN BASIN	I		O	NNC
CHOICE	SPECIES	CHOICE SPECIES	O		O	NNC
ANTILOPE	SPECIES	ANTILOPE SPECIES	O		O	NNC
TEMPLE	PORTICO	TEMPLE PORTICO	N		O	NNC
UNIVERSITY	CABINET	UNIVERSITY CABINET	F		O	NNC
CUPBOARD	DOOR	CUPBOARD DOOR	O		O	NNC
STRENGTH	PROPERTY	STRENGTH PROPERTY	O		O	NNC
EQUIVALENCE	PRINCIPLE	EQUIVALENCE PRINCIPLE	O		O	NNC
HEALTH	STANDARD	HEALTH STANDARD	R		O	NNC
AREA	BASIS	AREA BASIS	R		O	NNC
LAVA	FOUNTAIN	LAVA FOUNTAIN	O		O	NNC
ROOM	TEMPERATURE	ROOM TEMPERATURE	O		O	NNC
METALLURGY	INDUSTRY	METALLURGY INDUSTRY	I		R	NNC
CHAMPIONSHIP	BOUT	CHAMPIONSHIP BOUT	I		R	NNC
RELATION	AGENCY	RELATION AGENCY	R		R	NNC
NEWSPAPER	SUBSCRIPTION	NEWSPAPER SUBSCRIPTION	R		R	NNC
BACCALAUREATE	CURRICULUM	BACCALAUREATE CURRICULUM	O		R	NNC
WELFARE	AGENCY	WELFARE AGENCY	N		R	NNC
VEHICLE	INDUSTRY	VEHICLE INDUSTRY	I		R	NNC
DAIRY	BARN	DAIRY BARN	O		R	NNC
BATTERY	TECHNOLOGY	BATTERY TECHNOLOGY	R		R	NNC
LIFE	IMPRISONMENT	LIFE IMPRISONMENT	R		R	NNC
SUBSISTENCE	CULTIVATION	SUBSISTENCE CULTIVATION	O		R	NNC
RECREATION	AREA	RECREATION AREA	R		R	NNC
CATTLE	INDUSTRY	CATTLE INDUSTRY	R		R	NNC
REACTION	MIXTURE	REACTION MIXTURE	O		R	NNC
LOGIC	UNIT	LOGIC UNIT	N		R	NNC
TRIO	SONATA	TRIO SONATA	R		R	NNC
DIARY	CATTLE	DIARY CATTLE	F		R	NNC
GOVERNMENT	BUILDING	GOVERNMENT BUILDING	N		R	NNC
STORAGE	CAPACITY	STORAGE CAPACITY	R		R	NNC
TOWN	HALL	TOWN HALL	R		R	NNC
SHORTHAND	DEVICE	SHORTHAND DEVICE	I		R	NNC
FOOD	INDUSTRY	FOOD INDUSTRY	R		R	NNC
EXCAVATION	SKILL	EXCAVATION SKILL	W		R	NNC
INSURANCE	INDUSTRY	INSURANCE INDUSTRY	R		R	NNC
INTELLIGENCE	COMMUNITY	INTELLIGENCE COMMUNITY	W		R	NNC
PRODUCTION	FACILITY	PRODUCTION FACILITY	R		R	NNC
VIOLIN	CONCERTO	VIOLIN CONCERTO	R		R	NNC
IMPEACHMENT	TRIAL	IMPEACHMENT TRIAL	R		R	NNC

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
BUSINESS	ECONOMICS	BUSINESS ECONOMICS	F		R	NNC
SYMPHONY	ORCHESTRA	SYMPHONY ORCHESTRA	F		R	NNC
CATTLE	TOWN	CATTLE TOWN	N		R	NNC
LABORATORY	QUANTITY	LABORATORY QUANTITY	I		R	NNC
RAILWAY	UNION	RAILWAY UNION	O		R	NNC
OFFICE	BUILDING	OFFICE BUILDING	F		R	NNC
PASSOVER	FESTIVAL	PASSOVER FESTIVAL	O		R	NNC
TELEVISION	WRITER	TELEVISION WRITER	N		R	NNC
HAIR	FOLLICLE	HAIR FOLLICLE	I		R	NNC
COMMUNICATION	SYSTEM	COMMUNICATION SYSTEM	R		R	NNC
MANAGEMENT	PROCEDURE	MANAGEMENT PROCEDURE	R		R	NNC
CONSTRUCTION	INDUSTRY	CONSTRUCTION INDUSTRY	R		R	NNC
COUNTY	TOWN	COUNTY TOWN	I		R	NNC
ESTIMATION	METHOD	ESTIMATION METHOD	I		R	NNC
SUFFRAGE	COMMITTEE	SUFFRAGE COMMITTEE	R		R	NNC
CHILDHOOD	SEXUALITY	CHILDHOOD SEXUALITY	I		I	NNC
PERCENTAGE	COMPOSITION	PERCENTAGE COMPOSITION	O		I	NNC
ALTITUDE	RECONNAISSANCE	ALTITUDE RECONNAISSANCE	F		I	NNC
LAB	PERIOD	LAB PERIOD	R		I	NNC
SANSKRIT	TEXT	SANSKRIT TEXT	F		I	NNC
INDUSTRY	REVENUE	INDUSTRY REVENUE	F		I	NNC
LABORATORY	APPLICATION	LABORATORY APPLICATION	I		I	NNC
CENSUS	POPULATION	CENSUS POPULATION	F		N	NNC
TELEVISION	NEWSCASTER	TELEVISION NEWSCASTER	N		N	NNC
CITY	LEGISLATURE	CITY LEGISLATURE	I		O	NNC
DISEASE	ORGANISM	DISEASE ORGANISM	F		O	NNC
ANTIBIOTIC	REGIMEN	ANTIBIOTIC REGIMEN	O		O	NNC
ANATOMY	PROFESSOR	ANATOMY PROFESSOR	O		O	NNC
SECURITY	PACT	SECURITY PACT	O		O	NNC
FAMILY	MEMBER	FAMILY MEMBER	O		O	NNC
PLUTONIUM	THEFT	PLUTONIUM THEFT	O		O	NNC
UNION	LEADER	UNION LEADER	F		O	NNC
CLIMATE	PATTERN	CLIMATE PATTERN	N		O	NNC
CERAMICS	PRODUCT	CERAMICS PRODUCT	O		O	NNC
APPLICATION	AREA	APPLICATION AREA	R		O	NNC
BUSINESS	HOLDING	BUSINESS HOLDING	I		O	NNC
PIGMENT	GRANULE	PIGMENT GRANULE	I		O	NNC
POTTERY	VESSEL	POTTERY VESSEL	N		O	NNC
POPULATION	DENSITY	POPULATION DENSITY	O		O	NNC
BUSINESS	SECTOR	BUSINESS SECTOR	O		O	NNC
CAR	ODOR	CAR ODOR	O		O	NNC
WORLD	COMMUNITY	WORLD COMMUNITY	I		O	NNC
POPULATION	EXPLOSION	POPULATION EXPLOSION	O		O	NNC
HARDWARE	TECHNOLOGY	HARDWARE TECHNOLOGY	I		O	NNC
DRAINAGE	BASIN	DRAINAGE BASIN	W		O	NNC
HEATH	FAMILY	HEATH FAMILY	O		O	NNC
WAR	GOD	WAR GOD	O		O	NNC
MAJORITY	LEADER	MAJORITY LEADER	F		O	NNC
GOVERNMENT	POLICY	GOVERNMENT POLICY	O		O	NNC
OCEAN	BASIN	OCEAN BASIN	I		O	NNC
CHOICE	SPECIES	CHOICE SPECIES	O		O	NNC
ANTILOPE	SPECIES	ANTILOPE SPECIES	O		O	NNC
TEMPLE	PORTICO	TEMPLE PORTICO	N		O	NNC
UNIVERSITY	CABINET	UNIVERSITY CABINET	F		O	NNC
CUPBOARD	DOOR	CUPBOARD DOOR	O		O	NNC
STRENGTH	PROPERTY	STRENGTH PROPERTY	O		O	NNC
EQUIVALENCE	PRINCIPLE	EQUIVALENCE PRINCIPLE	O		O	NNC
HEALTH	STANDARD	HEALTH STANDARD	R		O	NNC
AREA	BASIS	AREA BASIS	R		O	NNC
LAVA	FOUNTAIN	LAVA FOUNTAIN	O		O	NNC
ROOM	TEMPERATURE	ROOM TEMPERATURE	O		O	NNC
METALLURGY	INDUSTRY	METALLURGY INDUSTRY	I		R	NNC
CHAMPIONSHIP	BOUT	CHAMPIONSHIP BOUT	I		R	NNC
RELATION	AGENCY	RELATION AGENCY	R		R	NNC
NEWSPAPER	SUBSCRIPTION	NEWSPAPER SUBSCRIPTION	R		R	NNC
BACCALAUREATE	CURRICULUM	BACCALAUREATE CURRICULUM	O		R	NNC
WELFARE	AGENCY	WELFARE AGENCY	N		R	NNC
VEHICLE	INDUSTRY	VEHICLE INDUSTRY	I		R	NNC
DAIRY	BARN	DAIRY BARN	O		R	NNC
BATTERY	TECHNOLOGY	BATTERY TECHNOLOGY	R		R	NNC
LIFE	IMPRISONMENT	LIFE IMPRISONMENT	R		R	NNC
SUBSISTENCE	CULTIVATION	SUBSISTENCE CULTIVATION	O		R	NNC
RECREATION	AREA	RECREATION AREA	R		R	NNC
CATTLE	INDUSTRY	CATTLE INDUSTRY	R		R	NNC

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
REACTION	MIXTURE	REACTION MIXTURE	O		R	NNC
LOGIC	UNIT	LOGIC UNIT	N		R	NNC
TRIO	SONATA	TRIO SONATA	R		R	NNC
DIARY	CATTLE	DIARY CATTLE	F		R	NNC
GOVERNMENT	BUILDING	GOVERNMENT BUILDING	N		R	NNC
STORAGE	CAPACITY	STORAGE CAPACITY	R		R	NNC
TOWN	HALL	TOWN HALL	R		R	NNC
SHORTHAND	DEVICE	SHORTHAND DEVICE	I		R	NNC
FOOD	INDUSTRY	FOOD INDUSTRY	R		R	NNC
EXCAVATION	SKILL	EXCAVATION SKILL	W		R	NNC
INSURANCE	INDUSTRY	INSURANCE INDUSTRY	R		R	NNC
INTELLIGENCE	COMMUNITY	INTELLIGENCE COMMUNITY	W		R	NNC
PRODUCTION	FACILITY	PRODUCTION FACILITY	R		R	NNC
VIOLIN	CONCERTO	VIOLIN CONCERTO	R		R	NNC
IMPEACHMENT	TRIAL	IMPEACHMENT TRIAL	R		R	NNC
BUSINESS	ECONOMICS	BUSINESS ECONOMICS	F		R	NNC
SYMPHONY	ORCHESTRA	SYMPHONY ORCHESTRA	F		R	NNC
CATTLE	TOWN	CATTLE TOWN	N		R	NNC
LABORATORY	QUANTITY	LABORATORY QUANTITY	I		R	NNC
RAILWAY	UNION	RAILWAY UNION	O		R	NNC
OFFICE	BUILDING	OFFICE BUILDING	F		R	NNC
PASSOVER	FESTIVAL	PASSOVER FESTIVAL	O		R	NNC
TELEVISION	WRITER	TELEVISION WRITER	N		R	NNC
HAIR	FOLLICLE	HAIR FOLLICLE	I		R	NNC
COMMUNICATION	SYSTEM	COMMUNICATION SYSTEM	R		R	NNC
MANAGEMENT	PROCEDURE	MANAGEMENT PROCEDURE	R		R	NNC
CONSTRUCTION	INDUSTRY	CONSTRUCTION INDUSTRY	R		R	NNC
COUNTY	TOWN	COUNTY TOWN	I		R	NNC
ESTIMATION	METHOD	ESTIMATION METHOD	I		R	NNC
SUFFRAGE	COMMITTEE	SUFFRAGE COMMITTEE	R		R	NNC
COMMUNICATION	INDUSTRY	COMMUNICATION INDUSTRY	R		R	NNC
TELEVISION	PRODUCTION	TELEVISION PRODUCTION	N		R	NNC
ARTS	COLLEGE	ARTS COLLEGE	I		R	NNC
AUTOMOBILE	FACTORY	AUTOMOBILE FACTORY	R		R	NNC
TELEVISION	SERIES	TELEVISION SERIES	N		R	NNC
CORONATION	PORTAL	CORONATION PORTAL	A		T	NNC
CRIME	NOVELIST	CRIME NOVELIST	W		T	NNC
LIFE	SCIENTIST	LIFE SCIENTIST	T		T	NNC
MARRIAGE	CUSTOM	MARRIAGE CUSTOM	O		T	NNC
CONVENIENCE	FOOD	CONVENIENCE FOOD	R		W	NNC
MUSK	DEER	MUSK DEER	O		W	NNC
ABSORPTION	HYGROMETER	ABSORPTION HYGROMETER	O		W	NNC
MEAT	PRODUCT	MEAT PRODUCT	F		W	NNC
MOUNTAIN	COUNTRY	MOUNTAIN COUNTRY	F		W	NNC
SATELLITE	SYSTEM	SATELLITE SYSTEM	O		W	NNC
EXPANSION	TURBINE	EXPANSION TURBINE	R		W	NNC
TELEVISION	ERA	TELEVISION ERA	R		W	NNC
FIBER	OPTICS	FIBER OPTICS	W		W	NNC
CARRIER	SYSTEM	CARRIER SYSTEM	N		W	NNC
MONASTERY	**BUILDING**	**MONASTERY BUILDING**	**A**	**A**	**A**	**NNC**
FOSSIL	**FAUNA**	**FOSSIL FAUNA**	**B**	**B**	**B**	**is-a-hypernym**
ARAB	**SEAFARER**	**ARAB SEAFARER**	**B**	**B**	**B**	**is-a-hypernym**
DEPUTY	**GOVERNOR**	**DEPUTY GOVERNOR**	**B**	**B**	**B**	**is-a-hypernym**
CARBON	**ATOM**	**CARBON ATOM**	**B**	**B**	**B**	**is-a-hypernym**
ASSISTANT	**SECRETARY**	**ASSISTANT SECRETARY**	**B**	**B**	**B**	**is-a-hypernym**
WARRIOR	**PRINCE**	**WARRIOR PRINCE**	**B**	**B**	**B**	**is-a-hypernym**
PROTEIN	**MOLECULE**	**PROTEIN MOLECULE**	**B**	**B**	**B**	**is-a-hypernym**
LIEUTENANT	**GOVERNOR**	**LIEUTENANT GOVERNOR**	**B**	**B**	**B**	**is-a-hypernym**
INSECT	**PEST**	**INSECT PEST**	**B**	**B**	**B**	**is-a-hypernym**
CLEAVAGE	**DIVISION**	**CLEAVAGE DIVISION**	**B**	**B**	**B**	**is-a-hypernym**
DECOMPOSITION	**REACTION**	**DECOMPOSITION REACTION**	**B**	**B**	**B**	**is-a-hypernym**
UNIT	**CELL**	**UNIT CELL**	**B**	**B**	**B**	**is-a-hypernym**
RATIONALIST	**THINKER**	**RATIONALIST THINKER**	**B**	**B**	**B**	**is-a-hypernym**
DEPUTY	**DIRECTOR**	**DEPUTY DIRECTOR**	**B**	**B**	**B**	**is-a-hypernym**
ANARCHIST	**CONSPIRATOR**	**ANARCHIST CONSPIRATOR**	**B**	**B**	**B**	**is-a-hypernym**
SHELLFISH	**CRUSTACEAN**	**SHELLFISH CRUSTACEAN**	**B**	**B**	**B**	**NNC**
TROLLEY	**CAR**	**TROLLEY CAR**	**B**	**B**	**B**	**is-a-hypernym**
NEWS	**EVENT**	**NEWS EVENT**	**B**	**B**	**B**	**is-a-hypernym**
LUXURY	**GOOD**	**LUXURY GOOD**	**B**	**B**	**B**	**is-a-hypernym**
SEA	**ANIMAL**	**SEA ANIMAL**	**A**	**F**	**F**	**NNC**
SEA	**MAMMAL**	**SEA MAMMAL**	**A**	**F**	**F**	**NNC**
BIRD	**DROPPINGS**	**BIRD DROPPINGS**	**O**	**F**	**F**	**NNC**
SEA	**MONSTER**	**SEA MONSTER**	**W**	**F**	**F**	**NNC**
POULTRY	**PRODUCT**	**POULTRY PRODUCT**	**R**	**F**	**F**	**NNC**

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
PETROLEUM	PRODUCT	PETROLEUM PRODUCT	F	F	F	NNC
SEA	LION	SEA LION	I	F	F	is-a-hypernym
FOOD	PRODUCT	FOOD PRODUCT	F	F	F	NNC
PERIOD	CLASSIFICATION	PERIOD CLASSIFICATION	O	I	I	NNC
FOOD	SHORTAGE	FOOD SHORTAGE	O	O	O	NNC
GOVERNMENT	AGENCY	GOVERNMENT AGENCY	N	O	O	NNC
HEALTH	PROBLEM	HEALTH PROBLEM	W	O	O	NNC
CHILD	WELFARE	CHILD WELFARE	O	O	O	NNC
ACTIVITY	SPECTRUM	ACTIVITY SPECTRUM	O	O	O	NNC
ARAB	WORLD	ARAB WORLD	W	O	O	NNC
JUTE	PRODUCT	JUTE PRODUCT	O	O	O	NNC
THEATER	HISTORY	THEATER HISTORY	A	O	O	NNC
PRIORITY	AREA	PRIORITY AREA	O	O	O	NNC
LANGUAGE	FAMILY	LANGUAGE FAMILY	F	O	O	NNC
CATTLE	POPULATION	CATTLE POPULATION	O	O	O	NNC
LAW	SYSTEM	LAW SYSTEM	O	O	O	NNC
INFORMATION	SOURCE	INFORMATION SOURCE	O	O	O	NNC
WILDERNESS	AREA	WILDERNESS AREA	F	O	O	NNC
WORLD	ECONOMY	WORLD ECONOMY	I	O	O	NNC
BALLET	GENRE	BALLET GENRE	I	O	O	NNC
CELL	MEMBRANE	CELL MEMBRANE	O	O	O	NNC
FAMILY	BUSINESS	FAMILY BUSINESS	W	O	O	NNC
WORLD	SOUL	WORLD SOUL	F	O	O	NNC
TERRORIST	ACTIVITY	TERRORIST ACTIVITY	O	O	O	NNC
WORLD	WAR	WORLD WAR	I	O	O	NNC
ROCOCO	SPIRIT	ROCOCO SPIRIT	O	O	O	NNC
SAVANNAH	AREA	SAVANNAH AREA	O	O	O	NNC
FAMILY	TRADITION	FAMILY TRADITION	T	O	O	NNC
GESTATION	PERIOD	GESTATION PERIOD	O	O	O	NNC
TREATY	RELATIONSHIP	TREATY RELATIONSHIP	W	O	O	NNC
DOMINION	STATUS	DOMINION STATUS	O	O	O	NNC
CHILD	CUSTODY	CHILD CUSTODY	N	O	O	NNC
PETROLEUM	WEALTH	PETROLEUM WEALTH	F	O	O	NNC
CONSONANT	SYSTEM	CONSONANT SYSTEM	R	O	O	NNC
WORKER	SATISFACTION	WORKER SATISFACTION	F	O	O	NNC
FACULTY	MEMBER	FACULTY MEMBER	O	O	O	NNC
GUILD	MEMBER	GUILD MEMBER	O	O	O	NNC
DRAINAGE	PATTERN	DRAINAGE PATTERN	N	O	O	NNC
MINORITY	BUSINESS	MINORITY BUSINESS	T	O	O	NNC
ANCESTOR	SPIRIT	ANCESTOR SPIRIT	O	O	O	NNC
PROTEIN	SOURCE	PROTEIN SOURCE	O	O	O	NNC
VIBRATION	RATIO	VIBRATION RATIO	O	O	O	NNC
VALVE	SYSTEM	VALVE SYSTEM	O	O	O	NNC
BUDDHIST	PHILOSOPHY	BUDDHIST PHILOSOPHY	F	O	O	NNC
CONSTRUCTION	QUALITY	CONSTRUCTION QUALITY	O	O	O	NNC
INCUBATION	PERIOD	INCUBATION PERIOD	R	O	O	NNC
RATING	SYSTEM	RATING SYSTEM	O	O	O	NNC
WARBLER	FAMILY	WARBLER FAMILY	O	O	O	NNC
ROTATION	PERIOD	ROTATION PERIOD	O	O	O	NNC
WORLD	POPULATION	WORLD POPULATION	O	O	O	NNC
FAMILY	CONNECTION	FAMILY CONNECTION	W	O	O	NNC
WORLD	CHAMPIONSHIP	WORLD CHAMPIONSHIP	I	O	O	NNC
PROHIBITION	LAW	PROHIBITION LAW	R	O	O	NNC
SETTLEMENT	PATTERN	SETTLEMENT PATTERN	R	O	O	NNC
BANANA	INDUSTRY	BANANA INDUSTRY	O	R	R	NNC
WAR	SECRETARY	WAR SECRETARY	O	R	R	NNC
TRANSPORTATION	SYSTEM	TRANSPORTATION SYSTEM	R	R	R	NNC
WARFARE	EQUIPMENT	WARFARE EQUIPMENT	R	R	R	NNC
TRIAL	LAWYER	TRIAL LAWYER	R	R	R	NNC
STORAGE	BATTERY	STORAGE BATTERY	R	R	R	NNC
TYPEWRITER	MECHANISM	TYPEWRITER MECHANISM	R	R	R	NNC
PHONOGRAPH	PICKUP	PHONOGRAPH PICKUP	O	R	R	NNC
COMPUTER	MEMORY	COMPUTER MEMORY	R	R	R	NNC
MEMORY	SYSTEM	MEMORY SYSTEM	I	R	R	NNC
PLASMA	MEMBRANE	PLASMA MEMBRANE	F	R	R	NNC
BILE	DUCT	BILE DUCT	I	R	R	NNC
TRANSPORTATION	EQUIPMENT	TRANSPORTATION EQUIPMENT	R	R	R	NNC
TRANSMISSION	SYSTEM	TRANSMISSION SYSTEM	R	R	R	NNC
POULTRY	PEST	POULTRY PEST	I	R	R	NNC
PETROLEUM	INDUSTRY	PETROLEUM INDUSTRY	F	R	R	NNC
CHEMISTRY	LABORATORY	CHEMISTRY LABORATORY	R	R	R	NNC
EDUCATION	MOVEMENT	EDUCATION MOVEMENT	R	R	R	NNC
COMMUNICATION	SATELLITE	COMMUNICATION SATELLITE	R	R	R	NNC
SUSPENSION	SYSTEM	SUSPENSION SYSTEM	W	R	R	NNC

Modifier Noun	Head Noun	NNC	LAUER's Prediction	AXEL's Prediction	GROLIER Correct Answer	NC Type
ARTS	MUSEUM	ARTS MUSEUM	I	R	R	NNC
TEA	ROOM	TEA ROOM	R	R	R	NNC
CONSTRUCTION	MATERIAL	CONSTRUCTION MATERIAL	R	R	R	NNC
GOVERNMENT	OFFICIAL	GOVERNMENT OFFICIAL	F	R	R	NNC
TREATMENT	SYSTEM	TREATMENT SYSTEM	R	R	R	NNC
BUSINESS	EDUCATION	BUSINESS EDUCATION	I	T	T	NNC
COMMUNITY	EDUCATION	COMMUNITY EDUCATION	I	T	T	NNC
PROPERTY	LAW	PROPERTY LAW	W	T	T	NNC
PRISON	POEM	PRISON POEM	I	T	T	NNC
EXTINCTION	THEORY	EXTINCTION THEORY	T	T	T	NNC
QUANTUM	THEORY	QUANTUM THEORY	O	T	T	NNC
LIFE	SCIENCE	LIFE SCIENCE	I	T	T	NNC
MUSIC	THEORY	MUSIC THEORY	O	T	T	NNC
FAMILY	SAGA	FAMILY SAGA	T	T	T	NNC
POLICY	OPTION	POLICY OPTION	N	T	T	NNC
CUSTOM	UNION	CUSTOM UNION	W	T	T	NNC
MONEY	POLICY	MONEY POLICY	O	T	T	NNC
EDUCATION	JOURNAL	EDUCATION JOURNAL	I	T	T	NNC
ELECTION	LAW	ELECTION LAW	I	T	T	NNC
HORROR	TALE	HORROR TALE	A	T	T	NNC
SOUL	MUSIC	SOUL MUSIC	R	T	T	NNC
FUSION	DEVICE	FUSION DEVICE	R	W	W	NNC
LASER	TECHNOLOGY	LASER TECHNOLOGY	F	W	W	NNC
MACHINERY	OPERATION	MACHINERY OPERATION	F	W	W	NNC
RIVER	VALLEY	RIVER VALLEY	N	W	W	NNC
COMPUTER	NOVICE	COMPUTER NOVICE	I	W	W	NNC
CANCER	CELL	CANCER CELL	F	W	W	NNC
LUXURY	HOTEL	LUXURY HOTEL	R	W	W	NNC
KEROSENE	LAMP	KEROSENE LAMP	O	W	W	NNC

lxix.Table showing NNCs used in the test experiment

9.1.2. Appendix B: Three-noun Compound Results

This appendix collects NNNCs from the Lauer's set used in the bracketing test. For comparison, three different categories were analysed to classify bracketing: L (left-branching), R (right-branching) and I (indeterminate). The AXEL system did not process right-branching, instead it underwent left-branching to sort out yreview-based NNNC partitioning. The AXEL System results delivered IOF and ODOF numbers to assign ambiguous ranking to each NNNC. The test accuracy was 76%. This appendix reports on the AXEL System figures of the degree association of meanings, which resulted in a 70% polysemic behaviour -Scenario III and Scenario IV.

NNNC	LAUER	GROLIER	AXEL	AXEL-Association-NNNC	IOF	ODOF	Polysemic-Scenario	PWOP
CUSTOM ENFORCEMENT VEHICLE	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-R
AIRPORT SECURITY IMPROVEMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	R-W
SCIENCE FICTION NOVEL	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	T-O
SCIENCE FICTION THEME	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	T-O
WAR CRIME PROSECUTOR	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-R
SCIENCE FICTION SATIRE	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	T-O
CHILD DEVELOPMENT SPECIALIST	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	Y-R
HAIR CELL DESTRUCTION	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	R-W
HEALTH ENFORCEMENT AGENCY	R	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	W-O
HEALTH MAINTENANCE ORGANISATION	R	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	W-O
LYMPH NODE ENLARGEMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-F
REPERTORY THEATRE MOVEMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-R
KIDNEY ARTERY DISEASE	R	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-A
FISSION ENERGY PRODUCTION	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	O-T
LAW ENFORCEMENT RESOURCE	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	B-O
TELEVISION NEWS PHOTOGRAPHY	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	W-B
COMPUTER HARDWARE TECHNOLOGY	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	R-W
ALPHA PARTICLE BOMBARDMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	O-T
WAR COLLEGE INSTRUCTOR	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	W-A
SCIENCE CURRICULUM DEVELOPMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	T-O
STUDENT ACHIEVEMENT MEASUREMENT	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	Y-B
COMMUNICATION SATELLITE ORGANISATION	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	R-W
RIVER VALLEY COMMUNITY	L	L	L	AXEL	1	1	Scenario I: +IOF/-ODOF	W-A
ALPHA PARTICLE SOURCE	L	L	L	Monosemous	1	2	Scenario II: +IOF/+ODOF	O-T
LUXURY APARTMENT BUILDING	L	L	L	Monosemous	1	2	Scenario II: +IOF/+ODOF	W-A
LAW ENFORCEMENT INTERCEPTION	L	L	L	Monosemous	1	3	Scenario II: +IOF/+ODOF	B-B
MUSIC INDUSTRY DESIGNATION	L	L	L	Monosemous	1	4	Scenario II: +IOF/+ODOF	B-B
ARAB INDEPENDENCE MOVEMENT	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
COMBUSTION CHEMISTRY TECHNOLOGY	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
TOWN COUNCIL MEMBER	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
DEATH PENALTY STATUS	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
ERROR CORRECTION DATA	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
PRIVACY PROTECTION AGENCY	R	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
MONDAY NIGHT FOOTBALL	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
DATA MANAGEMENT EFFORT	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
QUALITY ASSURANCE DEPARTMENT	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
SUNDAY AFTERNOON FOOTBALL	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
SEA BASS FAMILY	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
EMERGENCY MEDICINE SPECIALIST	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
WAR CRIME INDICTMENT	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
SWINE FLU VIRUS	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
COUNTRY MUSIC REVIVAL	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
VAPOUR DENSITY METHOD	L	L	L	Polysemic	2	1-1	Scenario III: -IOF/-ODOF	
MISSILE GUIDANCE SYSTEM	R	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	

NNNC	LAUER	GROLIER	AXEL	AXEL-Association-NNNC	IOF	ODOF	Polysemic-Scenario	PWOP
COMMUNICATION SATELLITE SYSTEM	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
MINORITY BUSINESS ENTERPRISE	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
SPERM STORAGE VESSEL	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
GASOLINE STORAGE TANK	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
APERTURE SYNTHESIS SYSTEM	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
LASER RADAR SYSTEM	L	L	L	Polysemic	3	1-1-1	Scenario III: -IOF/-ODOF	
ENERGY DISTRIBUTION PROPERTY	L	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
FIBRE OPTICS SYSTEM	L	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
SPERM CELL PRODUCTION	L	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
MISSILE DEFENCE WEAPON	R	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
VENOM DELIVERY SYSTEM	L	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
NAVIGATION GUIDANCE SYSTEM	R	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
SECURITY COUNCIL ACTION	L	L	L	Polysemic	4	1-1-1-1	Scenario III: -IOF/-ODOF	
ORIGIN QUOTA SYSTEM	L	L	L	Polysemic	5	1-1-1-1-1	Scenario III: -IOF/-ODOF	
CITY GOVERNMENT ACTIVITY	L	L	L	Polysemic	5	1-1-1-1-1	Scenario III: -IOF/-ODOF	
WORLD NEWS ROUNDUP	L	L	L	Polysemic	5	1-1-1-1-1	Scenario III: -IOF/-ODOF	
MOUNTAIN SUMMIT AREA	L	L	L	Polysemic	6	1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
HYDROGEN ENERGY SYSTEM	R	L	L	Polysemic	6	1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
INFORMATION STORAGE TECHNOLOGY	L	L	L	Polysemic	6	1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
QUANTUM INTERFERENCE DEVICE	R	L	L	Polysemic	6	1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
ENERGY STORAGE ELEMENT	L	L	L	Polysemic	6	1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
SPEECH TRANSMISSION SYSTEM	L	L	L	Polysemic	7	1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
WEAPON DELIVERY SYSTEM	L	L	L	Polysemic	7	1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
CHICKEN POX INFECTION	L	L	L	Polysemic	8	1-1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
CANON LAW SYSTEM	L	L	L	Polysemic	8	1-1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
CITY GOVERNMENT ELECTION	L	L	L	Polysemic	9	1-1-1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
SPEECH RECOGNITION SYSTEM	L	L	L	Polysemic	12	1-1-1-1-1-1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
MINORITY BUSINESS DEVELOPMENT	L	L	L	Polysemic	17	1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	Scenario III: -IOF/-ODOF	
SEA BASS SPECIES	L	L	L	Extremely Polysemic	2	1-2	Scenario IV: -IOF/+ODOF	
RADIATION ENERGY CONVERSION	L	L	L	Extremely Polysemic	2	1-2	Scenario IV: -IOF/+ODOF	
HEALTH INSURANCE LAW	L	L	L	Extremely Polysemic	2	1-2	Scenario IV: -IOF/+ODOF	
COUNTRY MUSIC THEME	L	L	L	Extremely Polysemic	2	2-1	Scenario IV: -IOF/+ODOF	
LAW ENFORCEMENT AGENCY	L	L	L	Extremely Polysemic	2	3-1	Scenario IV: -IOF/+ODOF	
DEVELOPMENT ASSISTANCE EFFORT	L	L	L	Extremely Polysemic	2	3-1	Scenario IV: -IOF/+ODOF	
LAW ENFORCEMENT ORGANISATION	L	L	L	Extremely Polysemic	2	3-1	Scenario IV: -IOF/+ODOF	
LAW ENFORCEMENT ACTIVITY	L	L	L	Extremely Polysemic	2	3-1	Scenario IV: -IOF/+ODOF	
FERTILITY MYSTERY CULT	R	L	L	Extremely Polysemic	3	1-2-1	Scenario IV: -IOF/+ODOF	
WAR CRIME TRIAL	L	L	L	Extremely Polysemic	3	1-4-1	Scenario IV: -IOF/+ODOF	
ENERGY CONSERVATION LAW	L	L	L	Extremely Polysemic	3	2-1-2	Scenario IV: -IOF/+ODOF	
LAW ENFORCEMENT STANDARD	L	L	L	Extremely Polysemic	3	2-1-2	Scenario IV: -IOF/+ODOF	
WORKER COMPENSATION LAW	L	L	L	Extremely Polysemic	3	2-1-2	Scenario IV: -IOF/+ODOF	
NIGHT WARFARE CAPABILITY	L	L	L	Extremely Polysemic	3	2-2-2	Scenario IV: -IOF/+ODOF	
DISASTER RELIEF ASSISTANCE	L	L	L	Extremely Polysemic	3	3-1-1	Scenario IV: -IOF/+ODOF	
BLADDER OUTLET OBSTRUCTION	L	L	L	Extremely Polysemic	4	1-1-1-2	Scenario IV: -IOF/+ODOF	
DEVELOPMENT POLICY DECISION	L	L	L	Extremely Polysemic	4	1-2-1-1	Scenario IV: -IOF/+ODOF	
DEBT REPAYMENT PROBLEM	L	L	L	Extremely Polysemic	5	1-2-1-1-2	Scenario IV: -IOF/+ODOF	
LIFE INSURANCE POLICY	L	L	L	Extremely Polysemic	5	1-3-3-3-3	Scenario IV: -IOF/+ODOF	
PERFORMANCE IMPROVEMENT METHOD	L	L	L	Extremely Polysemic	5	1-4-1-1-1	Scenario IV: -IOF/+ODOF	
HEALTH EDUCATION INSTITUTION	L	L	L	Extremely Polysemic	5	2-1-1-1-1	Scenario IV: -IOF/+ODOF	
FOOD STORAGE FACILITY	L	L	L	Extremely Polysemic	5	2-1-1-1-1	Scenario IV: -IOF/+ODOF	
MISSILE DEFENCE SYSTEM	R	L	L	Extremely Polysemic	6	1-3-1-1-1-1	Scenario IV: -IOF/+ODOF	
COMMUNITY COLLEGE SYSTEM	L	L	L	Extremely Polysemic	6	1-5-1-1-1-1	Scenario IV: -IOF/+ODOF	
DATA STORAGE DEVICE	L	L	L	Extremely Polysemic	9	1-1-1-1-2-1-1-1-1	Scenario IV: -IOF/+ODOF	
DATA STORAGE SYSTEM	L	L	L	Extremely Polysemic	9	1-1-1-1-2-1-1-1-1	Scenario IV: -IOF/+ODOF	
WEAPON PRODUCTION FACILITY	R	L	L	Extremely Polysemic	9	1-1-2-1-1-1-1-1-1	Scenario IV: -IOF/+ODOF	
SEA TRANSPORTATION HUB	L	L	I					
ARMY ANT BEHAVIOUR	L	L	I					
SCIENCE FICTION WRITER	L	L	I					
BREEDER TECHNOLOGY DEVELOPMENT	L	L	I					
MUSIC HALL PERFORMER	R	L	I					
SEA WARFARE DOCTRINE	L	L	I					
COMPUTER MUSIC STUDIO	L	L	I					
COMPUTER EDUCATION ENTHUSIAST	L	L	I					
LAW ENFORCEMENT AGENT	L	L	I					
LAW ENFORCEMENT OFFICIAL	L	L	I					
CURRENCY BROKERAGE OFFICE	R	L	I					
COUNTRY MUSIC SINGER	L	L	I					
TENOR SAX PLAYER	L	L	I					
HOSPITAL PAYMENT SYSTEM	L	L	I					
LUXURY FURNITURE INDUSTRY	L	L	I					
ETHICS COMMITTEE INVESTIGATION	L	L	I					
COMPUTER INDUSTRY ENTREPRENEUR	L	L	I					
MUSIC HALL COMEDIAN	R	L	I					
TEACHER EDUCATION COLLEGE	L	L	I					

NNNC	LAUER	GROLIER	AXEL	AXEL-Association-NNNC	IOF	ODOF	Polysemic-Scenario	PWOP
COLLEGE BASKETBALL COMMENTATOR	L	L	I					
WAR CRIME TRIBUNAL	L	L	I					
FOOD ENERGY CALORIE	L	L	I					
BARN OWL FAMILY	L	L	I					
CHILD GUIDANCE MOVEMENT	R	L	I					
IMITATION ROCOCO INTERIOR	L	L	I					
DETECTION INVESTIGATION COMMITTEE	L	L	I					
PROTEIN DIGESTION PRODUCT	L	L	I					
NEWS BUREAU CHIEF	L	L	I					
COLLEGE STUDENT GOVERNMENT	L	L	I					
COUNTRY BUMPKIN NEPHEW	L	L	I					
BILE PIGMENT METABOLISM	L	L	I					

lxx. Table showing NNNCs used in the test experiment

9.1.3. Appendix C: Variable Coding of the AXEL System

This appendix contains part of the code developed for the AXEL System in Excel VBA language to deal with variable definition instructions. Some comments have been added to label the overall semantic functionality to explain the rules of unification of the lexical hierarchies. The Version 1.1 rules have been coded showing less resourced variables resulting in 28% accuracy. The second sample of code for the Version 1.2 shows an extended view of extra semantics rules which were argued in Chapter 6 in the second iteration. The second set of rules delivered an accuracy of 46%. It assists the algorithm programming by displaying the computational objects towards the role of semantic interpretation.

```
Option Explicit
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM Dir variables!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Global gStr_DirectoryList_InputFiles, gStr_DirectoryList_Logs, gStr_DirectoryList_OutputFiles As String
Global gStr_NounConstituent_Arg01, gStr_NounConstituent_Arg02, gStr_NounConstituent_Arg03 As String
Global gStr_CorrectPrepositon_Pair, gStr_Resulting_PWOP01, gStr_Resulting_PWOP02 as String
Global gStr_BinaryName_Without_TimeStamp As String
Global gStr_CorrectPrepositon_Pair_PWOP01, gStr_CorrectPrepositon_Pair_PWOP02, gStr_Binary_Flag As String
Global gStr_DirectoryList_Consolidated As String
Public Const cteStr_SYSTEM_VERSION As String = "1.1"
Public Const cteStr_SYSTEM_HIGHLIGHTS As String = "Work out Prepositions using PWOP Theory"
Public Const cteStr_PREFIX_FILE_CORRECT_PREPOSITION_PAIR  As String = "_lauer_"
Public Const cteStr_PREFIX_FILE_INPUT_THREENOUNCOMPOUND  As String = "\*axel_typesystem_*"
Public Const cteStr_PREFIX_FILE_OUTPUT_THREENOUNCOMPOUND  As String = "\axel_output_PWOP_"
Public Const cteStr_PREFIX_FILE_LOG_NAME_THREENOUNCOMPOUND  As String = "\log_axel_typesystem_"
Public Const cteStr_PREFIX_BINARY_NUMBER_NOPWOP01_NOPWOP02_NOLAUERMATCH  As String = "000000"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_NOPWOP02_NOLAUERMATCH  As String = "010000"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_NOPWOP02_LAUERMATCH  As String = "010001"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_PWOP02_NOLAUERMATCH  As String = "010100"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_PWOP02_LAUERMATCH  As String = "010101"
Global gInt_FreeFile_Log_ThreeNounCompound As Integer
Public Const cteStr_File_NAMETAB_Argument01 As String = "arg1"
Public Const cteStr_File_NAMETAB_Argument02 As String = "arg2"
Public Const cteStr_File_NAMETAB_Argument03 As String = "arg3"
Public Const cteStr_File_NAMETAB_PWOP01 As String = "pwop01"
Public Const cteStr_File_NAMETAB_PWOP02 As String = "pwop02"
Public Const cteStr_FLAG_TYPESYSTEM_SIMPLETYPE As String = "simple-type"
Public Const cteStr_FLAG_TYPESYSTEM_DOTTEDTYPE As String = "dotted-type"
Public Const cteStr_FLAG_TYPESYSTEM_CROSSEDTYPE As String = "crossed-type"
Public Const cteStr_FLAG_PARADIGM_UFC As String = "ufc"
Public Const cteStr_FLAG_PARADIGM_NNOFC As String = "nnofc"
Public Const cteStr_FLAG_LAUER_ACRONYM_INAT  As String = "A"
Public Const cteStr_FLAG_LAUER_ACRONYM_IN As String = "I"
Public Const cteStr_FLAG_LAUER_ACRONYM_WITH  As String = "W"
Public Const cteStr_FLAG_LAUER_ACRONYM_FROM  As String = "F"
Public Const cteStr_FLAG_LAUER_ACRONYM_ABOUTON As String = "T"
Public Const cteStr_FLAG_LAUER_ACRONYM_OF As String = "O"
Public Const cteStr_FLAG_LAUER_ACRONYM_FOR As String = "R"
Public Const cteStr_FLAG_LAUER_ACRONYM_BY As String = "Y"
Public Const cteStr_FLAG_LAUER_ACRONYM_LAUERCOPULA As String = "B"
Public Const cteStr_FLAG_LAUER_PREPOSITION_AT As String = "AT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_LOCATION  As String = "AT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_TEMPORAL  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_LAUER  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_WITH  As String = "WITH"
Public Const cteStr_FLAG_LAUER_PREPOSITION_FROM  As String = "FROM"
Public Const cteStr_FLAG_LAUER_PREPOSITION_ABOUT As String = "ABOUT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_ON As String = "ON"
Public Const cteStr_FLAG_LAUER_PREPOSITION_OF As String = "OF"
Public Const cteStr_FLAG_LAUER_PREPOSITION_FOR As String = "FOR"
Public Const cteStr_FLAG_LAUER_PREPOSITION_BY As String = "BY"

'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
```

```
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM VARIABLE DEFINITION RELATED TO THE 1st ITERATION!!!!
'' MMM GIRJU's semantic relations!!!
'' MMM By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

Public Const cteStr_GIRJU_SEMANTICRELATION_TYPE_PWOP As String = "is-a-type-of(TYPE)"
Public Const cteStr_GIRJU_SEMANTICRELATION_B_PWOP As String = "is-a-kind-of(IS-A)"
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-OF!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF POSSESSION!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_POSESSION_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_POSESSION_ARG02 As String = "entity/abstract
entity/abstraction/relation/possession"
Public Const cteStr_GIRJU_SEMANTICRELATION_POSESSION_PWOP As String = "of(POSSESSION)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF KINSHIP!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_KINSHIP_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_KINSHIP_ARG02 As String = "entity/physical entity/object/living
thing/organism/person/relative"
Public Const cteStr_GIRJU_SEMANTICRELATION_KINSHIP_PWOP As String = "of(KINSHIP)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF PROPERTY !!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00: 1)a and a; 2)d and b; 3)c and b;
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG01_a As String = "entity/physical entity/"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG01_b As String = "entity/abstract entity/abstraction/"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG02_a As String = "entity/abstract
entity/abstraction/attribute/property"
Public Const cteStr_GIRJU_SEMANTICRELATION_PROPERTY_PWOP As String = "of(PROPERTY)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=OF Whole-Part GIRJU's semantic relations!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG01_a As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG02_b As String = "entity/abstract
entity/abstraction/relation/part"
Public Const cteStr_GIRJU_SEMANTICRELATION_WHOLEPART_PWOP As String = "of(WHOLEPART)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=OF DEPICTION GIRJU!!!...
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_DEPICTION_ARG01 As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_DEPICTION_ARG02 As String = "entity/physical
entity/object/whole/artifact/creation/representation"
Public Const cteStr_GIRJU_SEMANTICRELATION_DEPICTION_PWOP As String = "of(DEPICTION)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=OF PRODUCE GIRJU!!!...
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG01_a As String = "entity/physical entity/substance"
''noun related: arg1=PROTEIN, arg1=chocolate
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG02 As String = "entity/physical
entity/object/whole/artifact/structure/building complex/plant" ''noun compound related: old-Girju <<arg2=factory of
arg1=Chocolate>>
Public Const cteStr_GIRJU_SEMANTICRELATION_PRODUCE_PWOP As String = "of(PRODUCE)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF THEME listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG01_a As String = "entity/abstract
entity/abstraction/communication"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG02_a As String = "entity/abstract entity/abstraction"
Public Const cteStr_GIRJU_SEMANTICRELATION_THEME_PWOP As String = "of(THEME)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=OF MEASURE By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG01_a As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG02_a As String = "entity/abstract
entity/abstraction/measure"
Public Const cteStr_GIRJU_SEMANTICRELATION_MEASURE_PWOP As String = "of(MEASURE)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr-OF EXPERIENCER! By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_EXPERIENCER_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_EXPERIENCER_ARG02 As String = "entity/abstract
entity/abstraction/attribute/state"
Public Const cteStr_GIRJU_SEMANTICRELATION_EXPERIENCER_PWOP As String = "of(EXPERIENCER)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-BY !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

```
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=BY AGENCY!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG01_a As String = "entity/abstract entity/abstraction/group"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG01_b As String = "entity/physical entity/object/living thing"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG02 As String = "entity/abstract entity/abstraction/psychological feature/event/act/action"
Public Const cteStr_GIRJU_SEMANTICRELATION_AGENT_PWOP As String = "by(AGENT)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-IN !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=in TEMPORAL TEMPORAL- GIRJU's semantic relations!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TEMPORAL_ARG01 As String = "entity/abstract entity/abstraction/measure/fundamental quantity/time period"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TEMPORAL_ARG02 As String = "entity/abstract entity/abstraction/psychological feature" ''noun related: arg1=JANUARY, arg2=TEMPERATURE... removed=/event"
Public Const cteStr_GIRJU_SEMANTICRELATION_TEMPORAL_PWOP As String = "in(TEMPORAL)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-WITH!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=WITH INSTRUMENT!
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG01_a As String = "entity/physical entity/object/whole/artifact/instrumentality" '' noun related: arg1=laser
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG02_a As String = "entity/abstract entity/abstraction/psychological feature/event" '' noun compound related: <<arg2=treatment (with) arg1=laser>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG02_b As String = "entity/abstract entity/abstraction/communication/auditory communication" '' noun compound related: <<arg2=concert (with) arg1=violin>
Public Const cteStr_GIRJU_SEMANTICRELATION_INSTRUMENT_PWOP As String = "with(INSTRUMENT)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=WITH MANNER!
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG01 As String = "entity/abstract entity/abstraction/attribute/state/" ''noun related: Arg2=PASSION
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG02_a As String = "entity/abstract entity/abstraction/psychological feature/event/act" ''noun compound related: <<arg2=Performance (with) arg1=PASSION>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG02_b As String = "entity/abstract entity/abstraction/psychological feature" ''noun compound related: <<arg2=FOOD (with) arg1=CONVENIENCE>> ... /event/act
Public Const cteStr_GIRJU_SEMANTICRELATION_MANNER_PWOP As String = "with(MANNER)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-AT !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_x As String = "entity/physical entity/object/location"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG02_a As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_LOCATION_PWOP As String = "at(LOCATION)"
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-FROM !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=FROM GIRJU's semantic relation= Make/produce listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_a As String = "entity/physical entity/object/living thing/organism/plant" ''Arg1=PENAUTS, ALMONDS, CASHEWS, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_b As String = "entity/physical entity/substance/solid/food/produce" ''Arg1=FRUIT, GRAPEFRIUT, VEGETABLE, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_c As String = "entity/physical entity/substance/solid/food/meat" ''Arg1=LIVER, etc. removed... /variety meat
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_a As String = "entity/physical entity/thing/unit/molecule/macromolecule/lipid" ''arg2=OIL
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_b As String = "entity/physical entity/substance/material/plant material/plant product" ''arg2=BALM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_c As String = "entity/physical entity/substance/food/beverage/alcohol" ''arg2=RUM, BEER, TEQUILA, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_d As String = "entity/physical entity/substance/food/foodstuff" ''arg2=JUICE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_a As String = "obtained from" ''OIL
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_b As String = "distilled from" ''RUM, TEQUILA, etc.
```

```
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_c As String = "made from" ''BALM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_d As String = "extracted from" ''JUICE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_e As String = "fermented" ''WINE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_f As String = "fermenting" ''BEER
Public Const cteStr_GIRJU_SEMANTICRELATION_SOURCE_PWOP As String = "from(SOURCE)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-ABOUT!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=ABOUT TOPIC listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_a As String = "entity/abstract entity/abstraction"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_a As String = "entity/abstract entity/abstraction/communication"
Public Const cteStr_GIRJU_SEMANTICRELATION_TOPIC_PWOP As String = "about(TOPIC)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-FOR!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=FOR BENEFICIARY listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG01 As String = "entity/physical entity/object/living thing/organism" ''noun related: arg1=poultry... arg1=finder... removed=/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG02_a As String = "entity/abstract entity/abstraction/relation/possession/transferred property" ''noun compound related: <<Arg2=REWARD (for) Arg1=finder>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG01 As String = "entity/physical entity/object/living thing/organism" ''noun related: arg1=poultry... arg1=finder... removed=/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG02_b As String = "entity/abstract entity/abstraction/attribute/state/condition/pathological state" ''noun compound related: Arg1=POULTRY, Arg2=PEST
Public Const cteStr_GIRJU_SEMANTICRELATION_BENEFICIARY_PWOP As String = "for(BENEFICIARY)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW GIRJU's sr=FOR PURPOSE...
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_a As String = "entity/physical entity/thing"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_a As String = "entity/physical entity/object/whole/artifact/instrumentality"
Public Const cteStr_GIRJU_SEMANTICRELATION_PURPOSE_PWOP As String = "for(PURPOSE)"
```

lxxi. Code showing instructions for variable definition of the AXEL System 1.1

```
Option Explicit
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM Dir variables!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Global gStr_DirectoryList_InputFiles, gStr_DirectoryList_Logs, gStr_DirectoryList_OutputFiles As String
Global gStr_NounConstituent_Arg01, gStr_NounConstituent_Arg02, gStr_NounConstituent_Arg03 As String
Global gStr_CorrectPrepositon_Pair, gStr_Resulting_PWOP01, gStr_Resulting_PWOP02 as String
Global gStr_BinaryName_Without_TimeStamp As String
Global gStr_CorrectPrepositon_Pair_PWOP01, gStr_CorrectPrepositon_Pair_PWOP02, gStr_Binary_Flag As String
Global gStr_DirectoryList_Consolidated As String
Public Const cteStr_SYSTEM_VERSION As String = "1.1"
Public Const cteStr_SYSTEM_HIGHLIGHTS As String = "Work out Prepositions using PWOP Theory"
Public Const cteStr_PREFIX_FILE_CORRECT_PREPOSITION_PAIR  As String = "_lauer_"
Public Const cteStr_PREFIX_FILE_INPUT_THREENOUNCOMPOUND  As String = "\*axel_typesystem_*"
Public Const cteStr_PREFIX_FILE_OUTPUT_THREENOUNCOMPOUND  As String = "\axel_output_PWOP_"
Public Const cteStr_PREFIX_FILE_LOG_NAME_THREENOUNCOMPOUND  As String = "\log_axel_typesystem_"
Public Const cteStr_PREFIX_BINARY_NUMBER_NOPWOP01_NOPWOP02_NOLAUERMATCH  As String = "000000"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_NOPWOP02_NOLAUERMATCH  As String = "010000"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_NOPWOP02_LAUERMATCH  As String = "010001"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_PWOP02_NOLAUERMATCH  As String = "010100"
Public Const cteStr_PREFIX_BINARY_NUMBER_PWOP01_PWOP02_LAUERMATCH  As String = "010101"
Global gInt_FreeFile_Log_ThreeNounCompound As Integer
Public Const cteStr_File_NAMETAB_Argument01 As String = "arg1"
Public Const cteStr_File_NAMETAB_Argument02 As String = "arg2"
Public Const cteStr_File_NAMETAB_Argument03 As String = "arg3"
Public Const cteStr_File_NAMETAB_PWOP01 As String = "pwop01"
Public Const cteStr_File_NAMETAB_PWOP02 As String = "pwop02"
Public Const cteStr_FLAG_TYPESYSTEM_SIMPLETYPE As String = "simple-type"
Public Const cteStr_FLAG_TYPESYSTEM_DOTTEDTYPE As String = "dotted-type"
Public Const cteStr_FLAG_TYPESYSTEM_CROSSEDTYPE As String = "crossed-type"
Public Const cteStr_FLAG_PARADIGM_UFC As String = "ufc"
Public Const cteStr_FLAG_PARADIGM_NNOFC As String = "nnofc"
Public Const cteStr_FLAG_LAUER_ACRONYM_INAT  As String = "A"
Public Const cteStr_FLAG_LAUER_ACRONYM_IN As String = "I"
Public Const cteStr_FLAG_LAUER_ACRONYM_WITH  As String = "W"
Public Const cteStr_FLAG_LAUER_ACRONYM_FROM  As String = "F"
Public Const cteStr_FLAG_LAUER_ACRONYM_ABOUTON As String = "T"
Public Const cteStr_FLAG_LAUER_ACRONYM_OF As String = "O"
```

```
Public Const cteStr_FLAG_LAUER_ACRONYM_FOR As String = "R"
Public Const cteStr_FLAG_LAUER_ACRONYM_BY As String = "Y"
Public Const cteStr_FLAG_LAUER_ACRONYM_LAUERCOPULA As String = "B"
Public Const cteStr_FLAG_LAUER_PREPOSITION_AT As String = "AT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_LOCATION  As String = "AT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_TEMPORAL  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_IN_LAUER  As String = "IN"
Public Const cteStr_FLAG_LAUER_PREPOSITION_WITH  As String = "WITH"
Public Const cteStr_FLAG_LAUER_PREPOSITION_FROM  As String = "FROM"
Public Const cteStr_FLAG_LAUER_PREPOSITION_ABOUT As String = "ABOUT"
Public Const cteStr_FLAG_LAUER_PREPOSITION_ON As String = "ON"
Public Const cteStr_FLAG_LAUER_PREPOSITION_OF As String = "OF"
Public Const cteStr_FLAG_LAUER_PREPOSITION_FOR As String = "FOR"
Public Const cteStr_FLAG_LAUER_PREPOSITION_BY As String = "BY"

'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM VARIABLE DEFINITION RELATED TO THE 2nd ITERATION!!!!
'' MMM GIRJU's semantic relations!!!
'' MMM By Jorge Matadamas, on wed, 17-Aug-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

Public Const cteStr_GIRJU_SEMANTICRELATION_TYPE_PWOP As String = "is-a-type-of(TYPE)"
Public Const cteStr_GIRJU_SEMANTICRELATION_B_PWOP As String = "is-a-kind-of(IS-A)"
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-OF!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF POSSESSION!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_POSESSION_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_POSESSION_ARG02 As String = "entity/abstract
entity/abstraction/relation/possession"
Public Const cteStr_GIRJU_SEMANTICRELATION_POSESSION_PWOP As String = "of(POSSESSION)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF KINSHIP!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_KINSHIP_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_KINSHIP_ARG02 As String = "entity/physical entity/object/living
thing/organism/person/relative"
Public Const cteStr_GIRJU_SEMANTICRELATION_KINSHIP_PWOP As String = "of(KINSHIP)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM LAUER's sr=OF BELONG!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BELONG_ARG01_a As String = "entity/physical entity/thing/body of
water"                                          ''noun related: arg1=SEA
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BELONG_ARG02_a As String = "entity/physical entity/object/living
thing"                                          ''noun compound related: arg1=SEA, arg2=ANIMAL; arg1=UNION, arg2=LEADER
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BELONG_ARG01_b As String = "entity/abstract
entity/abstraction/group/social group"                      ''noun related: arg1=UNION, arg1=UNIVERSITY
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BELONG_ARG02_b As String = "entity/physical
entity/object/whole/artifact/structure"                          ''noun compound related: arg1=UNIVERSITY,
Arg2=CABINET
Public Const cteStr_GIRJU_SEMANTICRELATION_BELONG_PWOP As String = "of(BELONG)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF PROPERTY !!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00: 1)a and a; 2)d and b; 3)c and b;
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG01_a As String = "entity/physical entity/"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG01_b As String = "entity/abstract entity/abstraction/"
''noun related:<<arg2=period (of) arg1=Gestation>>, arg1=THEATER,
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG02_a As String = "entity/abstract
entity/abstraction/attribute/property"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG02_b As String = "entity/abstract
entity/abstraction/psychological feature/cognition"                  ''noun compound related: <<arg2=TRADITION (of)
arg1=FAMILY>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG02_c As String = "entity/abstract
entity/abstraction/attribute/time"                              ''noun compound related: arg1=THEATER, arg2=HISTORY;
arg1=GESTATION, arg2=PERIOD
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PROPERTY_ARG02_d As String = "entity/abstract
entity/abstraction/attribute/state"                                     ''noun compound related: <<arg2=SPIRIT (of)
arg1=ROCOCO>>
Public Const cteStr_GIRJU_SEMANTICRELATION_PROPERTY_PWOP As String = "of(PROPERTY)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=OF Whole-Part GIRJU's semantic relations!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW New!!!!! Second iteration!!!!-  sr=OF Whole-Part... Lauer-suggested!... 31-jul-2010, 23:59:00
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG01_a As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG01_b As String = "entity/abstract
entity/abstraction/group"                          '' noun related: <<arg2=member (of) arg1=faculty>>, arg1=GUILD,
arg2=MEMBER
```

```
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG02_a As String = "entity/physical entity/thing/part"
'' noun compound related: arg1=PRIORITY, Arg2=AREA
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_WHOLEPART_ARG02_b As String = "entity/abstract
entity/abstraction/relation/part"                    '' noun related: member, arg2=Basis
Public Const cteStr_GIRJU_SEMANTICRELATION_WHOLEPART_PWOP As String = "of(WHOLEPART)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=OF DEPICTION GIRJU!!!... Second iteration
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_DEPICTION_ARG01 As String = "entity/physical entity/object"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_DEPICTION_ARG02 As String = "entity/physical
entity/object/whole/artifact/creation/representation"
Public Const cteStr_GIRJU_SEMANTICRELATION_DEPICTION_PWOP As String = "of(DEPICTION)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=OF PRODUCE GIRJU!!!... Second iteration
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG01_a As String = "entity/physical entity/substance"
''noun related: arg1=PROTEIN, arg1=chocolate
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG02 As String = "entity/physical
entity/object/whole/artifact/structure/building complex/plant"    ''noun compound related: old-Girju <<arg2=factory of
arg1=Chocolate>>
'Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG01_a As String = "entity/physical entity/substance"
''noun related: arg1=PROTEIN, arg1=chocolate
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG02_c As String = "entity/physical entity/process/natural
process"                         ''noun compound related: arg1=PROTEIN, arg2=SOURCE
'Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG01_a As String = "entity/physical entity/substance"
''noun related: arg1=PROTEIN, arg1=chocolate
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PRODUCE_ARG02_b As String = "entity/physical
entity/object/whole/artifact/commodity"                       ''noun compound related: arg1=JUTE, arg2=PRODUCT
Public Const cteStr_GIRJU_SEMANTICRELATION_PRODUCE_PWOP As String = "of(PRODUCE)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=OF THEME listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM New!!!!! Second iteration!!!!-  sr=OF THEME Lauer-suggested! By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG01_a As String = "entity/abstract
entity/abstraction/communication"                                    ''noun compound related= CONSONANT SYSTEM/written
communication"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG02_a As String = "entity/abstract entity/abstraction"
''noun compound related: <<Arg2= (of) Arg1= >>... arg2=GOD
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG01_b As String = "entity/abstract
entity/abstraction/psychological feature/event/group action"    ''noun compound related: <<arg2=GOD (of) arg1=WAR>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG02_a As String = "entity/abstract entity/abstraction"
''noun compound related: <<Arg2= (of) Arg1= >>... arg2=GOD
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG01_c As String = "entity/physical entity/abstraction/causal
agent/agent/drug"
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG02_a As String = "entity/abstract entity/abstraction"
''noun compound related: <<Arg2= (of) Arg1= >>... arg2=GOD
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG01_d As String = "entity/physical entity/object/living
thing/organism/person/religious person"
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_THEME_ARG02_a As String = "entity/abstract entity/abstraction"
''noun compound related: <<Arg2= (of) Arg1= >>... arg2=GOD
Public Const cteStr_GIRJU_SEMANTICRELATION_THEME_PWOP As String = "of(THEME)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM New!!!!! Second iteration!!!!-  sr=OF MEASURE Lauer-suggested! By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG01_a As String = "entity/physical entity/object"
''noun compound related: arg1=snow...
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG02_a As String = "entity/abstract
entity/abstraction/measure"                                ''noun related: arg2=PERIOD, arg2=inch... <<arg2=INCHES (of)
arg1=SNOW>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG01_b As String = "entity/abstract
entity/abstraction/psychological feature/event"                 ''noun compound related: arg1=ROTATION, arg2=PERIOD,
Arg1=VIBRATION
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MEASURE_ARG02_b As String = "entity/abstract
entity/abstraction/relation/magnitude relation"          ''noun compound related: <<arg2=RATIO (of) arg1=vibration>>
Public Const cteStr_GIRJU_SEMANTICRELATION_MEASURE_PWOP As String = "of(MEASURE)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr-OF EXPERIENCER! By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_EXPERIENCER_ARG01 As String = "entity/physical entity/object/living
thing/organism/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_EXPERIENCER_ARG02 As String = "entity/abstract
entity/abstraction/attribute/state"
Public Const cteStr_GIRJU_SEMANTICRELATION_EXPERIENCER_PWOP As String = "of(EXPERIENCER)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr-OF Unindentified! 2nd iteration- sr=OF EXPERIENCER By Jorge Matadamas, on sat 31 -jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_OF_LAUER00_ARG01 As String = "entity/abstract
entity/abstraction/attribute/state/condition"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_OF_LAUER00_ARG02_a As String = "entity/physical entity/object/living
thing"                        '' noun compound related, Arg1=DISEASE Arg2=ORGANISM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_OF_LAUER00_ARG02_b As String = "entity/abstract
entity/abstraction/psychological feature/cognition"  '' noun compound related, Arg1=Equivalence Arg2=principle
Public Const cteStr_GIRJU_SEMANTICRELATION_OF_LAUER00_PWOP As String = "of(Unidentified)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-BY !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=BY AGENCY!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
```

```
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG01_a As String = "entity/abstract entity/abstraction/group"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG01_b As String = "entity/physical entity/object/living
thing"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_AGENT_ARG02 As String = "entity/abstract
entity/abstraction/psychological feature/event/act/action"
Public Const cteStr_GIRJU_SEMANTICRELATION_AGENT_PWOP As String = "by(AGENT)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-IN !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=in TEMPORAL TEMPORAL- GIRJU's semantic relations!!! By Jorge Matadamas, on wed, 07-jul-2010, at 23:45:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TEMPORAL_ARG01 As String = "entity/abstract
entity/abstraction/measure/fundamental quantity/time period"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TEMPORAL_ARG02 As String = "entity/abstract
entity/abstraction/psychological feature"                   ''noun related: arg1=JANUARY, arg2=TEMPERATURE...
removed=/event"
Public Const cteStr_GIRJU_SEMANTICRELATION_TEMPORAL_PWOP As String = "in(TEMPORAL)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-WITH!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=WITH INSTRUMENT!
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG01_a As String = "entity/physical
entity/object/whole/artifact/instrumentality"        '' noun related: arg1=laser
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG02_a As String = "entity/abstract
entity/abstraction/psychological feature/event"      '' noun compound related: <<arg2=treatment (with) arg1=laser>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_INSTRUMENT_ARG02_b As String = "entity/abstract
entity/abstraction/communication/auditory communication"   '' noun compound related: <<arg2=concert (with) arg1=violin>
Public Const cteStr_GIRJU_SEMANTICRELATION_INSTRUMENT_PWOP As String = "with(INSTRUMENT)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=WITH LAUER ATTRIBUTE/MODIFIER... 2nd iteration!!!!-  By Jorge Matadamas, on sun 1-Aug-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG01_a As String = "entity/physical entity/substance/fuel"
'' noun related: arg1=Kerosene
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG02_a As String = "entity/physical
entity/object/whole/artifact/instrumentality"            '' noun compound related: <<arg2=LAMP (with) arg1=KEROSENE>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG01_b As String = "entity/abstract
entity/abstraction/attribute"                            '' noun related: arg1=luxury
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG02_b As String = "entity/physical
entity/object/whole/artifact/structure"                  '' noun compound related: <<arg2=HOTEL (with)arg1=LUXURY>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG01_c As String = "entity/physical
entity/object/whole/artifact/instrumentality/device"     '' noun related: arg1=Computer
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG02_c As String = "entity/physical entity/object/living
thing"                              '' noun compound related: <<arg2=NOVICE (with) arg1=COMPUTER>>, Arg2 was changed
only!!
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG01_d As String = "entity/physical entity/thing/body of
water/stream"                       '' noun related: arg1=RIVER
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MODIFIER_ARG02_d As String = "entity/physical
entity/object/geological formation"                      '' noun compound related: <<arg2=VALLEY (with) arg1=RIVER>>
Public Const cteStr_GIRJU_SEMANTICRELATION_MODIFIER_WITH_PWOP As String = "with(MODIFIER)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr=WITH MANNER!
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG01 As String = "entity/abstract
entity/abstraction/attribute/state/"                     ''noun related: Arg2=PASSION
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG02_a As String = "entity/abstract
entity/abstraction/psychological feature/event/act"      ''noun compound related: <<arg2=Performance (with)
arg1=PASSION>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_MANNER_ARG02_b As String = "entity/abstract
entity/abstraction/psychological feature"                ''noun compound related: <<arg2=FOOD (with)
arg1=CONVENIENCE>> ... /event/act
Public Const cteStr_GIRJU_SEMANTICRELATION_MANNER_PWOP As String = "with(MANNER)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-AT !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW New!!!!! 2nd iteration!!!!-  sr=AT LOCATION Arg1 mus be always a PLACE, SURFACE, LOCATION, etc.
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_a As String = "entity/physical
entity/object/whole/artifact/structure"                  ''noun compound related: arg1=Desert, arg1=EAVES,
arg1=TROUGH, arg1=Theater, arg1=UNIVERSITY... Removed=/housing"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_b As String = "entity/physical entity/thing/part/body
part"                               ''noun compound related: arg1=KIDNEY
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_d As String = "entity/physical
entity/object/geological formation"                      ''noun compound related: arg1=EAVES
''XXXPublic Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_x As String = "entity/physical
entity/object/location"                                  ''noun related: arg1=
```

```
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG02_a As String = "entity/physical entity/object"
''noun compound related: <<arg2=Castle (in) arg1=DESERT>>, <<Arg2=Glacier (in) Arg1=Mountain>>, <<Arg2=LANE (in)
Arg1=SEA>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG02_b As String = "entity/abstract
entity/abstraction/attribute/state/condition/pathological state" ''noun compound related= <<arg2=DISEASE (in)
arg1=KIDNEY>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG02_c As String = "entity/abstract
entity/abstraction/group/social group" ''noun compound related: <<arg2=ORCHESTRA (in)
arg1=THEATER>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG01_e As String = "entity/physical entity/thing/body of
water" ''noun compound related: arg1=SEA
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LOCATION_ARG02_e As String = "entity/physical
entity/object/whole/artifact/way" ''noun related: arg1= Lane
Public Const cteStr_GIRJU_SEMANTICRELATION_LOCATION_PWOP As String = "at(LOCATION)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-FROM !!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=FROM SOURCE GIRJU's semantic relation= Make/produce!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_a As String = "entity/physical entity/object/living
thing/organism/plant" ''Arg1=PENAUTS, ALMONDS, CASHEWS, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_b As String = "entity/physical
entity/substance/solid/food/produce" ''Arg1=FRUIT, GRAPEFRIUT, VEGETABLE, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG01_c As String = "entity/physical
entity/substance/solid/food/meat" ''Arg1=LIVER, etc. removed... /variety meat
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_a As String = "entity/physical
entity/thing/unit/molecule/macromolecule/lipid" ''arg2=OIL
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_b As String = "entity/physical
entity/substance/material/plant material/plant product" ''arg2=BALM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_c As String = "entity/physical
entity/substance/food/beverage/alcohol" ''arg2=RUM, BEER, TEQUILA, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_ARG02_d As String = "entity/physical
entity/substance/food/foodstuff" ''arg2=JUICE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_a As String = "obtained from"
''OIL
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_b As String = "distilled from"
''RUM, TEQUILA, etc.
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_c As String = "made from"
''BALM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_d As String = "extracted from"
''JUICE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_e As String = "fermented"
''WINE
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SOURCE_GLOSS_f As String = "fermenting"
''BEER
Public Const cteStr_GIRJU_SEMANTICRELATION_SOURCE_PWOP As String = "from(SOURCE)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW sr-FROM= Lauer-suggested!... Second iteration
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG01_a As String = "entity/physical entity/object/living
thing" ''noun related: arg1=Bird
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG02_a As String = "entity/physical
entity/substance/material/waste" ''noun related: Arg2=Droppings
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG01_b As String = "entity/physical entity/substance"
''noun related: Arg1=Food, Arg1=Petroleum
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG02_b As String = "entity/physical
entity/object/whole/artifact/creation" ''noun related: Arg2=Product
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG01_c As String = "entity/physical entity/object/living
thing/organism/animal" ''noun related: arg1=Poultry....removed/living thing as conflicted with of(BELONG)"
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG02_b As String = "entity/physical
entity/object/whole/artifact/creation" ''noun related: Arg2=Product
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG01_d As String = "entity/physical entity/thing/body of
water/sea"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_LAUERORIGIN_ARG02_d As String = "entity/physical entity/object/living
thing/organism/animal" ''noun related: arg1=Poultry....removed/living thing as conflicted with of(BELONG)"
Public Const cteStr_GIRJU_SEMANTICRELATION_LAUERORIGIN_PWOP As String = "from(ORIGIN)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-ABOUT!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=ABOUT TOPIC listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_a As String = "entity/abstract entity/abstraction"
''noun related: quantum, arg1=noun compound related: arg1=HORROR, arg2= TALE... removed=/psychological feature"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_a As String = "entity/abstract
entity/abstraction/communication" ''noun compound related: arg1=FAMILY
arg2=SAGA... Remove=Message
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_b As String = "entity/physical entity/process/phenomenon"
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_a As String = "entity/abstract
entity/abstraction/communication" ''noun compound related: arg1=FAMILY
arg2=SAGA... Remove=Message
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_a As String = "entity/abstract entity/abstraction"
''noun related: Arg1=quantum, Arg1=Extinction, arg1=HORROR, arg2= TALE... removed=/psychological feature"
```

```
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_c As String = "entity/abstract
entity/abstraction/psychological feature/cognition/process"        ''noun compound related: Arg1=EXTINCTION,
Arg2=THEORY
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_a As String = "entity/abstract entity/abstraction"
''noun related: Arg1=quantum, Arg1=Extinction, arg1=HORROR, arg2= TALE... removed=/psychological feature"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_d As String = "entity/abstract
entity/abstraction/psychological feature/cognition/content"        ''noun compound related: <<arg2=SCIENCE
(about) Arg1=1LIFE>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_e As String = "entity/abstract
entity/abstraction/relation/possession/liabilities"        ''noun related: Arg1=CUSTOM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_e As String = "entity/abstract
entity/abstraction/group/social group"        ''noun related: <<Arg2=UNION (about)
Arg1=CUSTOM>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG01_f As String = "entity/physical
entity/object/whole/artifact/structure/establishment"        ''noun related: arg1=Prison
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_TOPIC_ARG02_f As String = "entity/abstract
entity/abstraction/communication/written communication"        ''noun compound related: <<arg2=POEM
(about) arg1=prison>>... Remove=Message"
Public Const cteStr_GIRJU_SEMANTICRELATION_TOPIC_PWOP As String = "about(TOPIC)"

'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXX sr-FOR!!!!!!!!!!
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM GIRJU's sr=FOR BENEFICIARY listings!!! By Jorge Matadamas, on fri, 16-jul-2010, at 23:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG01 As String = "entity/physical entity/object/living
thing/organism"        ''noun related: arg1=poultry... arg1=finder... removed=/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG02_a As String = "entity/abstract
entity/abstraction/relation/possession/transferred property"        ''noun compound related: <<Arg2=REWARD (for)
Arg1=finder>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG01 As String = "entity/physical entity/object/living
thing/organism"        ''noun related: arg1=poultry... arg1=finder... removed=/person"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_BENEFICIARY_ARG02_b As String = "entity/abstract
entity/abstraction/attribute/state/condition/pathological state"        ''noun compound related: Arg1=POULTRY, Arg2=PEST
Public Const cteStr_GIRJU_SEMANTICRELATION_BENEFICIARY_PWOP As String = "for(BENEFICIARY)"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW GIRJU's sr=FOR PURPOSE... Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_b As String =
"entity/abstract entity/abstraction/psychological feature/event"
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
'' WWW New!!!!! Second iteration!!!!-  sr=FOR PURPOSE... Lauer-suggested!... 31-jul-2010, 23:59:00
'' WWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWWW
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_a As String = "entity/physical entity/thing"
''noun related: Arg1=NAIL"
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_a As String = "entity/physical
entity/object/whole/artifact/instrumentality"        ''noun related: Arg2=BRUSH... <<Arg2=Brush (for)
Arg1=Nail>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_b As String = "entity/abstract
entity/abstraction/psychological feature"        ''noun related: Arg1=RECREATION... "
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_a As String = "entity/physical
entity/object/whole/artifact/instrumentality"        ''noun related: Arg2=BRUSH... <<Arg2=Brush (for)
Arg1=Nail>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_c As String = "entity/physical entity/object"
''removed... /living thing"
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_a As String = "entity/physical
entity/object/whole/artifact/instrumentality"        ''noun related: Arg2=BRUSH... <<Arg2=Brush (for)
Arg1=Nail>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_d As String = "entity/physical entity/substance"
''noun related: Arg1=Bile, food, petroleum
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_d As String = "entity/physical
entity/object/whole/artifact/way"        ''noun compound related: <<arg2=DUCT (for) arg1=BILE>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_b As String = "entity/abstract
entity/abstraction/psychological feature"        ''noun related: Arg1=RECREATION... "
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_f As String = "entity/physical
entity/object/location/region"        ''noun compound related: <<arg2=AREA (for)
arg1=RECREATION>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_d As String = "entity/physical entity/substance"
''noun related: Arg1=Bile, food, petroleum
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_e As String = "entity/physical
entity/object/whole/artifact/sheet"        ''noun compound related: <<arg2=MEMBRANE (for)
arg1=PLASMA>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_d As String = "entity/physical entity/substance"
''noun related: Arg1=Bile, food, petroleum
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_g As String = "entity/abstract
entity/abstraction/group/social group"        ''noun compound related: arg1=FOOD, arg2=INDUSTRY
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_h As String = "entity/physical entity/process/natural
process/chemical process"        ''noun related: arg1=REACTION... "
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_h As String = "entity/physical
entity/substance/mixture"        ''noun compound related: <<arg2=MIXTURE (for)
arg1=REACTION>>
''Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG01_b As String = "entity/abstract
entity/abstraction/psychological feature"        ''noun related: Arg1=ARTS... "
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_i As String = "entity/physical
entity/object/whole/artifact/facility"        ''noun compound related: <<arg2=MUSEUM (for) arg1=ARTS>>
''XXXPublic Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_PURPOSE_ARG02_b As String = "entity/physical
entity/object/whole/artifact/structure"
Public Const cteStr_GIRJU_SEMANTICRELATION_PURPOSE_PWOP As String = "for(PURPOSE)"
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
'' MMM sr=FOR (SKILLED)... Second iteration!!!!-  Lauer-suggested! By Jorge Matadamas, on sun 01-Aug-2010, at 21:55:00
'' MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
```

```
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SKILLED_ARG01_a As String = "entity/abstract
entity/abstraction/psychological feature/event"                  ''noun related: arg1=trial
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SKILLED_ARG02_a As String = "entity/physical entity/object/living
thing/organism/person/adult/professional"   ''noun compound related: <<arg2=LAWYER (for) arg1=TRIAL>>
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SKILLED_ARG01_b As String = "entity/abstract
entity/abstraction/group/social group/organization"              ''noun related: Arg1=government
Public Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SKILLED_ARG02_b As String = "entity/physical entity/object/living
thing/organism/person/worker"                ''noun compound related: <<Arg2=OFFICIAL (for) Arg1=GOVERNMENT>>
''XXXPublic Const cteStr_GIRJU_SEMANTICRELATION_HIERARCHY_SKILLED_ARG02_a As String = "entity/abstract
entity/abstraction/psychological feature/cognition"
Public Const cteStr_GIRJU_SEMANTICRELATION_SKILLED_PWOP As String = "for(SKILLED)"
```

lxxii. Code showing instructions for variable definition of the AXEL System 1.2

9.1.4. Appendix D: Heuristics for Lexical Hierarchies

This appendix summarises the theoretical findings regarding the heuristics of the semantic mappings in the AXEL System. These analyses were removed from Chapter 5 due to the rules inducing repetitive knowledge from table xli. The rest of the analysis of the prepositional semantics was transferred from section 5.2.2 into this appendix to plan a simpler reading of the Tentative Design D. However in section 5.2.2 the Design construction rested deliberately upon a summary of the most salient rules derived from the lexical hierarchy analysis, the present analysis focuses on informing such rules to explain collaborative pruning of the lexical hierarchies.

The analysis below attempts to disclose regular structures at NC syntactic level. To this end, both modifier noun and head noun will be analysed, according to the SRs from Girju's mappings in table lix. The results will be presented as rules involving pruned types for both modifier noun and head noun, to imply lexical hierarchy unification, which will settle the prepositional semantics in the AXEL System.

⌦ **2.- SR Kinship in Girju's table lix:** NNC= "boy sister" structure is Arg_1+Arg_2, which should be read "Arg_1 IS IN KINSHIP WITH Arg_2" or "boy IS IN KINSHIP WITH sister". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=boy as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(boy-sense#1)=entity/physical entity/physical object/living thing/organism/person/male/male-child	**boy**
T(boy-sense#1)=entity/physical entity/causal agent	boy
T(boy-sense#2)=physical entity/physical object/living thing/organism/person/male/adult-male/boy-grown-man	boy
T(boy-sense#3)=entity/physical entity/physical object/living thing/organism/person/relative/offspring/child/male-offspring/son	boy
T(boy-sense#4)=entity/physical entity/physical object/living thing/organism/person/male-cannot-have-babies	boy
T(boy-sense#5)=entity/physical entity/physical object/living thing/organism/person/Black-person	boy
T(boy-sense#6)=entity/physical entity/physical object/living thing/organism/person/person-of-color	boy

lxxiii.Table containing lexical hierarchy heuristics for Girju's SR KINSHIP for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=sister is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(sister-sense#1)= entity/physical entity/physical object/living thing/organism/person/relative/kinswoman/female sibling/sister-female	**sister**
T(sister-sense#1)= entity/physical entity/causal agent	sister
T(sister-sense#2)=entity/physical entity/physical object/living thing/organism/person/religious person/religious-member/nun/Sister-title	sister
T(sister-sense#3)=entity/physical entity/physical object/living thing/organism/person/peer/associate/member/sister-fellow	sister
T(sister-sense#4)=entity/physical entity/physical object/living thing/organism/person/female/woman/young/sister-attractive-young-women	sister
T(sister-sense#5)=entity/physical entity/physical object/living thing/organism/person/grownup/sister-attractive-young-women	sister

lxxiv.Table containing lexical hierarchy heuristics for Girju's SR KINSHIP for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_2-KINSHIP** defined by the following rule:

> **SR_2-KINSHIP RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/physical object/living thing/organism/person,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/physical object/living thing/organism/person/relative**, will generate the OF=**OF(Kinship)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/physical object/living thing/organism/person/relative**

⌦ **3.- SR Property in Girju's table lix:** NNC= "lubricant viscosity" structure is Arg_1+Arg_2, which should be read "Arg_1 IS PROPERTY OF Arg_2" or "lubricant IS PROPERTY OF viscosity". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=lubricant as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(lubricant-sense#1)=entity/physical entity/substance/material/lubricant-liquid	lubricant

lxxv. Table containing lexical hierarchy heuristics for Girju's SR PROPERTY for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=viscosity is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(viscosity-sense#1)=entity/abstract entity/abstraction/attribute/property-basic-attribute/consistency/viscosity-of-a-liquid	viscosity

lxxvi. Table containing lexical hierarchy heuristics for Girju's SR PROPERTY for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_3-PROPERTY** defined by the following rule:

> **SR_3-PROPERTY RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/substance/material/lubricant-liquid,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/attribute/property-basic-attribute/consistency/viscosity-of-a-liquid**, will generate the OF=**OF(Property)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/attribute/property-basic-attribute/consistency/viscosity-of-a-liquid**

⌦ **4.- SR Agent in Girju's table lix:** NNC= "police investigation" structure is Arg_1+Arg_2, which should be read "Arg_1 IS AGENT OF Arg_2" or "police IS AGENT OF investigation". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=police as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(police-sense#1)=entity/abstract entity/abstraction/group-members/social group/organization/personnel-group-of-people/police	**police**
T(police-sense#1)= entity/abstract entity/abstraction/group-members/social group/organization/social unit/administrative unit/agency/law enforcement agency	police

lxxvii. Table containing lexical hierarchy heuristics for Girju's SR AGENT for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=investigation is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(investigation-sense#1)= entity/abstract entity/abstraction/psychological feature/cognition-learning/process/higher cognitive process/thinking/problem solving/inquiry/investigation-probe	investigation
T(investigation-sense#1)=entity/abstract entity/abstraction/psychological feature/event/human action/activity/work-doing-something/investigation	**investigation**

lxxviii.Table containing lexical hierarchy heuristics for Girju's SR AGENT for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_4-AGENT** defined by the following rule:

> **SR_4-AGENT RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/group-members/social group/organization/personnel-group-of-people/police,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/psychological feature/event/human action/activity/work-doing-something/investigation**, will generate the BY=**BY(Agent)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/psychological feature/event/human action/activity/work-doing-something/investigation**

⌦ **5.- SR Temporal in Girju's table lix:** NNC= "morning news" structure is Arg_1+Arg_2, which should be read "Arg_1 IS TEMPORAL LOCATION OF Arg_2" or "morning IS TEMPORAL LOCATION OF news". FSBs have been queried from the

knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=morning as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(morning-sense#1)=entity/abstract entity/abstraction/measure/fundamental-quantity/time-period/morning-between-dawn-and-noon	**morning**
T(morning-sense#2)=entity/abstract entity/abstraction/communication/message, content, subject matter, substance/acknowledgment/greeting/good morning-greeting-farewell	morning
T(morning-sense#2)=entity/abstract entity/abstraction/communication/message/acknowledgment/farewell-goodwill-at-parting	morning
T(morning-sense#3)=entity/abstract entity/abstraction/psychological feature/cognition/information/data point/meter reading/clock time/hour/dawn-the-first-light-of-day	morning
T(morning-sense#4)=entity/abstract entity/abstraction/psychological feature/event/happening/beginning/start/dawn-the-earliest-period	morning

lxxix. Table containing lexical hierarchy heuristics for Girju's SR TEMPORAL for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=news is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(news-sense#1)=entity/abstract entity/abstraction/communication/message/information/news-new-information	news
T(news-sense#2)=entity/abstract entity/abstraction/communication/message/information/news-new-information-of-any-kind	news
T(news-sense#3)=entity/abstract entity/abstraction/psychological feature/event/social event/show/broadcast/news-program	**news**
T(news-sense#4)=entity/abstract entity/abstraction/communication/message/information/news-in-a-newspaper	news
T(news-sense#5)=entity/abstract entity/abstraction/attribute/quality/power/interest/news-being-sufficientlyinteresting	news

lxxx.Table containing lexical hierarchy heuristics for Girju's SR TEMPORAL for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_5-TEMPORAL** defined by the following rule:

> **SR_5-TEMPORAL RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/measure/fundamental-quantity/time-period/morning-between-dawn-and-noon,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/psychological feature/event/social event/show/broadcast/news-program**, will generate the IN=**IN(Temporal)** preposition as underlying semantic relation between

both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/psychological feature/event/social event/show/broadcast/news-program**

⌦ **6.- SR Depiction in Girju's table lix:** NNC= "niece picture" structure is Arg_1+Arg_2, which should be read "Arg_2 DEPICTS Arg_1" or "picture DEPICTS niece". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=niece as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(niece-sense#1)=entity/physical entity/physical object/living thing/organism, being/person/relative/kinswoman/niece	**niece**
T(niece-sense#1)=entity/physical entity/causal agent/entity	niece

lxxxi. Table containing lexical hierarchy heuristics for Girju's SR DEPICTION for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=picture is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(picture-sense#1)=entity/physical entity/physical object/whole/artifact/creation/representation/picture-visual-representation	**picture**
T(picture-sense#2)=entity/physical entity/physical object/whole/artifact/creation/fine art/graphic art/painting	picture
T(picture-sense#3)=entity/abstract entity/abstraction/psychological feature/cognition/content/mental representation/mental image/mental picture	picture
T(picture-sense#4)=entity/abstract entity/abstraction/attribute/state/state of affairs/picture	picture
T(picture-sense#5)=entity/abstract entity/abstraction/communication/visual communication/artwork/illustration/pictorial matter	picture
T(picture-sense#6)=entity/abstract entity/abstraction/psychological feature/event/social event/show/picture-film	picture
T(picture-sense#7)=entity/abstract entity/abstraction/communication/visual communication/picture-video	picture
T(picture-sense#8)=entity/abstract entity/abstraction/communication/message/statement/description/picture-characterization	picture

lxxxii. Table containing lexical hierarchy heuristics for Girju's SR DEPICTION for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_6-DEPICTION** defined by the following rule:

SR_6-DEPICTION RULE: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet:

entity/physical entity/physical object/living thing/organism, being/person/relative/kinswoman/niece, along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/physical object/whole/artifact/creation/representation/picture-visual-representation**, will generate the OF=**OF(Depiction)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/physical object/whole/artifact/creation/representation/picture-visual-representation**

⌦ **7.- SR Part-whole in Girju's table lix:** NNC= "child face" structure is Arg_1+Arg_2, which should be read "Arg_2 IS PART OF Arg_1" or "face IS PART OF child". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=child as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(child-sense#1)=entity/physical entity/causal agent/entity/physical entity/physical object/living thing/organism/person/juvenile/child-young person of either sex	**child**
T(child-sense#1)=entity/physical entity/causal agent	child
T(child-sense#2)=entity/physical entity/physical object/living thing/organism/person/relative/offspring/child-son or daughter	child
T(child-sense#2)=entity/physical entity/causal agent	child
T(child-sense#3)=entity/physical entity/physical object/living thing/organism/person/child-immature childish person	child
T(child-sense#3)=entity/physical entity/causal agent	child
T(child-sense#4)=entity/physical entity/physical object/living thing/organism/person/relative/descendant/child-member of a clan or tribe	child
T(child-sense#4)=entity/physical entity/causal agent	child

lxxxiii. Table containing lexical hierarchy heuristics for Girju's SR PART-WHOLE for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=face is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(face-sense#1)=entity/physical entity/thing/part/body part/external body part/face-human face	face
T(face-sense#2)=entity/abstract entity/abstraction/attribute/quality/visual aspect/countenance/expression-face	face
T(face-sense#3)=entity/abstract entity/abstraction/attribute/quality/visual aspect/face-outward appearance	face
T(face-sense#4)=entity/physical entity/physical object/whole/artifact/surface-outer boundary/face-surface of an implement	face

T(face-sense#5)=entity/physical entity/physical object/living thing/organism/person/face-to refer to a person	face
T(face-sense#5)=entity/physical entity/causal agent	face
T(face-sense#6)=entity/physical entity/physical object/location/region/extremity/boundary/surface/face-outside of an object	face
T(face-sense#7)=entity/physical entity/thing/part/body part/external body part/face-part of an animal	face
T(face-sense#8)=entity/physical entity/physical object/whole/artifact/surface/side/front/face-prominent surface	face
T(face-sense#9)=entity/abstract entity/abstraction/communication/visual communication/gesture/facial expression/face- contorted facial expression	face
T(face-sense#10)=entity/abstract entity/abstraction/communication/signal/symbol/written symbol/character/type/face-type within a type boy	face
T(face-sense#11)=entity/abstract entity/abstraction/attribute/state/status/face-status in the eyes of others	face
T(face-sense#12)=entity/abstract entity/abstraction/attribute/trait/drive/aggressiveness/face-impudent aggressiveness	face
T(face-sense#13)=entity/physical entity/physical object/whole/artifact/surface/vertical surface/face-vertical surface of a building	face

lxxxiv. Table containing lexical hierarchy heuristics for Girju's SR PART-WHOLE for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_7-PART-WHOLE** defined by the following rule:

> **SR_7-PART-WHOLE RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/causal agent/entity/physical entity/physical object/living thing/organism/person/juvenile/child-young person of either sex,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/thing/part/body part/external body part/face-human face**, will generate the OF=**OF(Part-whole)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/thing/part/body part/external body part/face-human face**

⌦ **8.- SR Is-a-hypernym in Girju's table lix:** NNC= "daisy flower" structure is Arg_1+Arg_2, which should be read "Arg_1 IS A KIND OF Arg_2" or "daisy IS A KIND OF flower". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=daisy as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(daisy-sense#1)=entity/physical entity/physical object/living thing/organism/plant/vascular plant/seed plant/flowering plant/flower/daisy-well-developed ray flowers	daisy

lxxxv. Table containing lexical hierarchy heuristics for Girju's SR IS-A-HYPERNYM for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=flower is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(flower-sense#1)=entity/physical entity/physical object/living thing/organism/plant/vascular plant/seed plant/flowering plant/flower	flower

lxxxvi. Table containing lexical hierarchy heuristics for Girju's SR IS-A-HYPERNYM for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_8-IS-A-HYPERNYM** defined by the following rule:

> **SR_8-IS-A-HYPERNYM RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** whose T(Arg_1)=Lexical Hierarchy contains the initial part of T(Arg_2)=Lexical Hierarchy of **Arg_2 will generate** OF=**OF(Is-a-hypernym)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type f**T(Arg_2)=Lexical Hierarchy**

⌦ **10.- SR Make-produce in Girju's table lix:** NNC= "chocolate factory" structure is Arg_1+Arg_2, which should be read "Arg_1 PRODUCES Arg_2" or "factory PRODUCES chocolate". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=chocolate as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(chocolate-sense#1)=entity/physical entity/substance/food/beverage/chocolate- drinking chocolate-made from cocoa powder	chocolate
T(chocolate-sense#1)=entity/physical entity/substance/fluid/liquid	chocolate
T(chocolate-sense#2)=entity/physical entity/substance/solid/solid food/chocolate- made from roasted ground cacao beans	**chocolate**
T(chocolate-sense#3)=entity/abstract entity/abstraction/attribute/property/visual property/color/chromatic color/brown- brownness/chocolate-brown to dark-brown color	chocolate

lxxxvii. Table containing lexical hierarchy heuristics for Girju's SR PRODUCE for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=factory is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(factory-sense#1)=entity/physical entity/physical object/whole/artifact/construction/building complex/industrial plant/factory- facilities for manufacturing	**factory**

lxxxviii. Table containing lexical hierarchy heuristics for Girju's SR PRODUCE for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{10}-MAKE-PRODUCE** defined by the following rule:

> **SR_{10}-MAKE-PRODUCE RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/substance/solid/solid food,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/physical object/whole/artifact/construction/building complex**, will generate the OF=**OF(Make-produce)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/physical object/whole/artifact/construction/building complex**

⌦ **11.- SR Instrument in Girju's table lix:** NNC= "laser treatment" structure is Arg_1+Arg_2, which should be read "Arg_1 IS INSTRUMENT OF Arg_2" or "laser IS INSTRUMENT OF treatment". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=laser as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(laser-sense#1)=entity/physical entity/physical object/whole/artifact/instrumentality/device-invented for a particular purpose/optical device/laser-optical device/laser	**laser**

lxxxix. Table containing lexical hierarchy heuristics for Girju's SR INSTRUMENT for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=treatment is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(treatment-sense#1)=entity/abstract entity/abstraction/psychological feature/event/human action/activity/work/care/treatment-procedures to relieve illness or injury	**treatment**
T(treatment-sense#2)=entity/abstract entity/abstraction/psychological feature/event/human action/group action/social control/management/treatment-management of something	treatment
T(treatment-sense#2)=entity/abstract entity/abstraction/psychological feature/event	treatment
T(treatment-sense#3)=entity/abstract entity/abstraction/attribute/property/manner/artistic style/treatment-dealing with something artistically	treatment
T(treatment-sense#4)=entity/abstract entity/abstraction/psychological feature/event/human action/communication/treatment-an extended communication	treatment

xc.Table containing lexical hierarchy heuristics for Girju's SR INSTRUMENT for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{11}-INSTRUMENT** defined by the following rule:

> **SR_{11}-INSTRUMENT RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/physical object/whole/artifact/instrumentality,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/psychological feature/event/human action**, will generate the WITH=**WITH(Instrument)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/psychological feature/event/human action**

⌦ 12.- SR Location in Girju's table lix: NNC= "desert castle" structure is Arg_1+Arg_2, which should be read "Arg_2 IS LOCATED IN Arg_1" or "castle IS LOCATED IN desert". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=desert as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(desert-sense#1)=entity/physical entity/object, physical object/location/region/geographical area/piece of land/desert-arid land	**desert**
T(desert-sense#1)=entity/abstract entity/abstraction/group/community-ecology/biome-biotic community	desert

xci. Table containing lexical hierarchy heuristics for Girju's SR LOCATION for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=castle is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(castle-sense#1)=entity/physical entity/physical object/whole/artifact/construction /housing/dwelling-someone is living in/house-dwelling for one or more families/mansion-/castle-large and stately mansion	**castle**
T(castle-sense#1)=entity/physical entity/physical object/whole/artifact/construction /building-edifice	castle
T(castle-sense#2)=entity/physical entity/physical object/whole/artifact/construction /defensive structure/fortification/castle-building occupied by a ruler	castle
T(castle-sense#3)=entity/physical entity/physical object/whole/artifact/instrumentality/equipment-needed to perform service/game equipment/piece-object used in certain board games/chess piece/castle-piece of the chessboard	castle
T(castle-sense#4)=entity/abstract entity/abstraction/psychological feature/event/human action/activity/turn/move/chess move/castling-interchanging positions of king and rook	castle

xcii. Table containing lexical hierarchy heuristics for Girju's SR LOCATION for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{12}-LOCATION** defined by the following rule:

> **SR_{12}-LOCATION RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/object, physical object/location/region,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/physical object/whole/artifact/construction**, will generate the AT=**AT(Location)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/physical object/whole/artifact/construction**

⌦ **13.- SR Purpose in Girju's table lix:** NNC= "nail brush" structure is Arg_1+Arg_2, which should be read "Arg_1 IS PURPOSE OF Arg_2" or "nail IS PURPOSE OF brush". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=nail as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(nail-sense#1)=entity/physical entity/thing/part/body part/anatomical structure/horny structure/nail-part of the dorsal surface of the digits	**nail**
T(nail-sense#2)=physical object/whole/artifact/instrumentality/device-instrumentality invented for a particular purpose/restraint/fastener/nail-hammered into materials as a fastener	nail
T(nail-sense#3)=entity/abstract entity/abstraction/measure/linear measure/linear unit-measurement of length/nail-unit of length for cloth	nail

xciii. Table containing lexical hierarchy heuristics for Girju's SR PURPOSE for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=brush is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(brush-sense#1)=entity/abstract entity/abstraction/group/collection/vegetation/brush-growth of bushes	brush
T(brush-sense#2)=entity/physical entity/physical object/whole/artifact/instrumentality/implement-tool used to effect an end/brush-hairs set into a handle	**brush**
T(brush-sense#3)=entity/abstract entity/abstraction/psychological feature/event/happening/contact/touch/brush-momentary contact	brush
T(brush-sense#4)=entity/physical entity/physical object/whole/artifact/instrumentality/device-invented for a particular purpose/electrical device/brush-conducts current of a generator	brush
T(brush-sense#5)=abstract entity/abstraction/psychological feature/event/human action/group action/conflict/fight/brush-minor short-term fight	brush
T(brush-sense#6)=entity/abstract entity/abstraction/psychological feature/event/entity	brush
T(brush-sense#7)=entity/abstract entity/abstraction/psychological feature/event/human action/activity/work/care/dental care/brush-brushing your teeth	brush
T(brush-sense#8)=entity/abstract entity/abstraction/psychological feature/event/human action/activity/work/care/hair care/brush-brushing your hair	brush
T(brush-sense#9)=entity/abstract entity/abstraction/psychological feature/event/human action/action/interaction/contact/brush-contact with something dangerous	brush

xciv. Table containing lexical hierarchy heuristics for Girju's SR PURPOSE for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{13}-PURPOSE** defined by the following rule:

> **SR_{13}-PURPOSE RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/thing,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/physical object/whole/artifact/instrumentality**, will generate the FOR=**FOR(Purpose)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/physical entity/physical object/whole/artifact/instrumentality**

⌦ **14.- SR Source in Girju's table lix:** NNC= "grapefruit oil" structure is Arg_1+Arg_2, which should be read "Arg_1 IS SOURCE OF Arg_2" or "grapefruit IS SOURCE OF oil". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=grapefruit as follows:

T(Arg_1)=Lexical Hierarchy	**Noun**
T(grapefruit-sense#1)=entity/physical entity/physical object/living thing/organism/plant/vascular plant/woody plant/tree/angiospermous tree/fruit tree/citrus tree/grapefruit- tree bearing round edible fruit	grapefruit
T(grapefruit-sense#2)=entity/physical entity/substance/solid/food/produce/edible fruit/citrus- citrus fruit/grapefruit-large yellow fruit	**grapefruit**
T(grapefruit-sense#2)=entity/physical entity/physical object/whole/natural object/plant part/plant organ/reproductive structure/fruit/entity	grapefruit

xcv. Table containing lexical hierarchy heuristics for Girju's SR SOURCE for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=oil is shown below:

T(Arg_2)=Lexical Hierarchy	**Noun**
T(oil-sense#1)=entity/physical entity/thing/unit/molecule/macromolecule/lipid/oil- substance not miscible with water	oil
T(oil-sense#1)=entity/physical entity/substance/chemical compound/organic compound	oil
T(oil-sense#2)=physical entity/physical object/whole/artifact/covering/coating/paint/oil paint/oil-oil paint containing pigment	oil
T(oil-sense#2)=entity/physical entity/substance/material/coloring material/entity	oil
T(oil-sense#3)=entity/physical entity/thing/unit/molecule/macromolecule/lipid/fat/edible fat/oil-vegetable oil obtained from plants	**oil**
T(oil-sense#3)= entity/physical entity/substance/chemical compound/organic compound	oil

xcvi. Table containing lexical hierarchy heuristics for Girju's SR SOURCE for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{14}-SOURCE** defined by the following rule:

> **SR_{14}-SOURCE RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/substance/solid/food/produce,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/physical entity/thing/unit/molecule/macromolecule/lipid**, will generate the FROM=**FROM(Source)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following

pruned simple type from **Arg_2: entity/physical entity/thing/unit/molecule/macromolecule/lipid**

⌦ **15.- SR Topic in Girju's table lix:** NNC= "weather report" structure is Arg_1+Arg_2, which should be read "Arg_1 IS TOPIC OF Arg_2" or "weather IS TOPIC OF report". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=weather as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(weather-sense#1)=entity/physical entity/physical process/phenomenon/natural phenomenon/physical phenomenon/atmospheric phenomenon/weather-atmospheric conditions	**weather**

xcvii. Table containing lexical hierarchy heuristics for Girju's SR TOPIC for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=report is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(report-sense#1)=entity/abstract entity/abstraction/communication/written communication/written material/written document/report- written document describing findings	report
T(report-sense#2)=entity/abstract entity/abstraction/communication/message/information/news/report- a short account of the news	report
T(report-sense#3)=entity/abstract entity/abstraction/psychological feature/event/human action/speech act/informing/report- informing by verbal report	report
T(report-sense#4)=entity/abstract entity/abstraction/psychological feature/event/happening/sound/noise/report- sharp explosive sound	report
T(report-sense#5)=entity/abstract entity/abstraction/communication/message/information/report- written evaluation of a student's scholarship	report
T(report-sense#6)=entity/abstract entity/abstraction/communication/written communication/writing- piece of writing/essay/report-written as an assignment	report
T(report-sense#7)=entity/abstract entity/abstraction/psychological feature/knowledge/attitude/respect/estimate/report-estimation that the public has for a person	report

xcviii. Table containing lexical hierarchy heuristics for Girju's SR TOPIC for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{15}-TOPIC** defined by the following rule:

SR_{15}-TOPIC RULE: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/physical process/phenomenon,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/communication**, will generate the OF=**OF(Topic)**

preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/communication**

⌦ **16.- SR Manner in Girju's table lix:** NNC= "passion performance" structure is Arg_1+Arg_2, which should be read "Arg_1 IS MANNER OF Arg_2" or "passion IS MANNER OF performance". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=passion as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(passion-sense#1)=entity/abstract entity/abstraction/attribute/state/feeling/passion-strong feeling or emotion	passion
T(passion-sense#1)=entity/abstract entity/abstraction/attribute/trait/emotionality/passion-being intensely emotional	**passion**
T(passion-sense#2)= entity/abstract entity/abstraction/attribute/state/physiological state/arousal/desire/passion-desired intensely	passion
T(passion-sense#3)= entity/abstract entity/abstraction/psychological feature/motivation/irrational motive/passion-irresistible motive	passion
T(passion-sense#4)= entity/abstract entity/abstraction/attribute/state/feeling/desire/sexual desire/passion-strong sexual desire	passion
T(passion-sense#5)= entity/abstract entity/abstraction/psychological feature/knowledge/content/object/passion-warm affection or devotion	passion

xcix. Table containing lexical hierarchy heuristics for Girju's SR MANNER for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=performance is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(performance-sense#1)= entity/abstract entity/abstraction/psychological feature/event/social event/show/performance- dramatic or musical entertainment	performance
T(performance-sense#1)=entity/abstract entity/abstraction/psychological feature/event/human action/action/performance-doing something successfully	**performance**
T(performance-sense#2)= entity/abstract entity/abstraction/psychological feature/event/human action/activity/recreation/entertainment/show/presentation/performance-presenting a play	performance
T(performance-sense#3)= entity/physical entity/physical process/performance-process or manner of functioning	performance
T(performance-sense#4)= entity/abstract entity/abstraction/psychological feature/event/human action/action/achievement/performance-any recognized accomplishment	performance

c. Table containing lexical hierarchy heuristics for Girju's SR MANNER for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{16}-MANNER** defined by the following rule:

SR_{16}-MANNER RULE: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/attribute,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/psychological feature/event/human action**, will generate the WITH=**WITH(Manner)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/psychological feature/event/human action**

⌦ **17.- SR Experiencer in Girju's table lix:** NNC= "girl fear" structure is Arg_1+Arg_2, which should be read "Arg_1 IS EXPERIENCER OF Arg_2" or "girl IS EXPERIENCER OF fear". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=girl as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(girl-sense#1)= entity/physical entity/physical object/living thing/organism/person/female/woman/girl-a young woman	girl
T(girl-sense#1)= entity/physical entity/causal agent	girl
T(girl-sense#2)=entity/physical entity/physical object/living thing/organism/person/female/girl-little girl	**girl**
T(girl-sense#2)= entity/physical entity/causal agent	girl
T(girl-sense#3)= entity/physical entity/physical object/living thing/organism/person/relative/offspring/child/female offspring/girl-daughter	girl
T(girl-sense#4)= entity/physical entity/causal agent	girl
T(girl-sense#5)= entity/physical entity/physical object/living thing/organism/person/female person/woman/girl-woman with whom a man is romantically involved	girl
T(girl-sense#6)= entity/physical entity/causal agent	girl

ci. Table containing lexical hierarchy heuristics for Girju's SR EXPERIENCER for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=fear is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(fear-sense#1)=entity/abstract entity/abstraction/attribute/state/feeling/emotion/fear-emotion experienced of pain or danger	**fear**
T(fear-sense#1)= entity/abstract entity/abstraction/attribute/state/feeling/emotion/anxiety/fear-anxious feeling	fear
T(fear-sense#2)= entity/abstract entity/abstraction/attribute/state/feeling/emotion/fear-emotion inspired by a deity	fear

cii. Table containing lexical hierarchy heuristics for Girju's SR EXPERIENCER for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{17}-EXPERIENCER** defined by the following rule:

> **SR_{17}-EXPERIENCER RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/physical object/living thing,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/attribute/state/feeling**, will generate the OF=**OF(Experiencer)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/attribute/state/feeling**

⌦ **18.- SR Measure in Girju's table lix:** NNC= "snow inch" structure is Arg_1+Arg_2, which should be read "Arg_2 IS MEASURE OF Arg_1" or "snow IS MEASURE OF inch". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=snow as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(snow-sense#1)= entity/physical entity/process, physical process/phenomenon/natural phenomenon/physical phenomenon/atmospheric phenomenon/weather/precipitation/snow-precipitation falling from clouds	snow
T(snow-sense#1)=entity/physical entity/physical object/location/region/layer/snow-layer of snowflakes	**snow**
T(snow-sense#2)= entity/physical entity/causal agent/agent/drug/narcotic/hard drug/cocaine/coke	snow
T(snow-sense#3)= entity/physical entity/causal agent/agent/drug/controlled substance	snow

ciii. Table containing lexical hierarchy heuristics for Girju's SR MEASURE for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=inch is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(inch-sense#1)= entity/abstract entity/abstraction/measure/linear measure/linear unit/inch-unit of length equal to one twelfth of a foot	inch
T(inch-sense#1)=entity/abstract entity/abstraction/measure/definite quantity/unit of measurement/area unit/inch-unit of measurement for advertising space	**inch**

civ. Table containing lexical hierarchy heuristics for Girju's SR MEASURE for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{18}-MEASURE** defined by the following rule:

> **SR_{18}-MEASURE RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/physical entity/physical object,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/measure/definite quantity/unit of measurement**, will generate the OF=**OF(Measure)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/measure/definite quantity/unit of measurement**

⌦ **19.- SR Theme in Girju's table lix:** NNC= "stock acquisition" structure is Arg_1+Arg_2, which should be read "Arg_1 IS THEME OF Arg_2" or "stock IS THEME OF acquisition". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=stock as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(stock-sense#1)=entity/abstract entity/abstraction/relation/possession-anything owned/assets/working capital/stock-capital raised by a corporation	**stock**
T(stock-sense#1)= entity/physical entity/substance/food/nutriment/dish/soup/stock-liquid in which meat and vegetables are simmered	stock
T(stock-sense#2)= entity/physical entity/physical object/whole/artifact/commodity/merchandise/stock-inventory	stock
T(stock-sense#3)= entity/abstract entity/abstraction/relation/possession-anything owned/assets/sum of money/gain/financial gain/income/net income/accumulation/stock-supply of something available for future use	stock
T(stock-sense#4)= entity/physical entity/physical object/living thing/organism/animal/chordate/vertebrate/mammal/placental/stock-farm animal- livestock	stock
T(stock-sense#5)= entity/abstract entity/abstraction/group/social group/kinship group/genealogy/stock-descendants of one individual	stock
T(stock-sense#6)= entity/physical entity/physical object/part/appendage/handle/stock-handle of a handgun	stock
T(stock-sense#7)= entity/physical entity/physical object/whole/artifact/instrumentality/device/support	stock
T(stock-sense#8)= entity/abstract entity/abstraction/attribute/state/status/standing/honor/reputation/stock-reputation and popularity a person has	stock
T(stock-sense#9)= entity/abstract entity/abstraction/group/biological group/taxonomic group/variety/stock-variety of domesticated animals within a species	stock
T(stock-sense#10)= entity/abstract entity/abstraction/group/biological group/animal group	stock
T(stock-sense#11)= entity/physical entity/physical object/whole/artifact/building material/timber/stock-lumber used in the construction of something	stock

T(stock-sense#12)= entity/abstract entity/abstraction/communication/written communication/written material/document/stock certificate/certificate/stock- certificate documenting the shareholder's ownership	stock
T(stock-sense#13)= entity/physical entity/physical object/living thing/organism/plant/vascular plant/spermatophyte/angiosperm/flower/stock-Malcolm stock-flowering plant	stock
T(stock-sense#14)= entity/physical entity/physical object/whole/natural object/plant part/stock-plant or stem onto which a graft is made	stock
T(stock-sense#15)= entity/physical entity/physical object/living thing/organism/plant/vascular plant/spermatophyte/angiosperm/flower/stock-gillyflower	stock
T(stock-sense#16)= entity/physical entity/physical object/part/appendage/handle/stock-handle end of some implements	stock
T(stock-sense#17)= entity/physical entity/physical object/whole/natural object/plant part/plant organ/stalk/stock-persistent thickened stem of a herbaceous perennial plant	stock
T(stock-sense#18)= entity/physical entity/physical object/whole/artifact/covering/clothing/garment/neckwear/cravat/stock-neckcloth	stock
T(stock-sense#19)= entity/physical entity/physical object/whole/artifact/commodity/consumer goods	stock

cv. Table containing lexical hierarchy heuristics for Girju's SR THEME for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=acquisition is shown below:

T(Arg_2)=Lexical Hierarchy	**Noun**
T(acquisition-sense#1)=entity/abstract entity/abstraction/psychological feature/event/human action/action-opposed to something said/accomplishment/deed/acquiring/acquisition-act of acquiring possession of something	**acquisition**
T(acquisition-sense#1)= entity/abstract entity/abstraction/relation/possession-anything owned/transferred property/acquisition-something acquired	acquisition
T(acquisition-sense#2)= entity/abstract entity/abstraction/psychological feature/knowledge/mental process/basic cognitive process/acquisition-acquiring knowledge	acquisition
T(acquisition-sense#3)= entity/abstract entity/abstraction/psychological feature/knowledge/ability/acquisition-ability acquired by training	acquisition

cvi. Table containing lexical hierarchy heuristics for Girju's SR THEME for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{19}-THEME** defined by the following rule:

> **SR_{19}-THEME RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/relation,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction**, will generate the OF=**OF(Theme)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction**

⌦ **20.- SR Beneficiary in Girju's table lix:** NNC= "finder reward" structure is Arg_1+Arg_2, which should be read "Arg_1 IS BENEFICIARY OF Arg_2" or "finder IS BENEFICIARY OF reward". FSBs have been queried from the knowledge base to which T transformation will be applied. Simple types are retrieved from WordNet as hypernyms for Arg_1=finder as follows:

T(Arg_1)=Lexical Hierarchy	Noun
T(finder-sense#1)=physical entity/physical object/living thing/organism/person/seeker/finder-someone who comes upon something after searching	**finder**
T(finder-sense#1)= entity/physical entity/causal agent	finder
T(finder-sense#2)= entity/physical entity/physical object/living thing/organism/person/perceiver/finder-someone who is the first to observe something	finder
T(finder-sense#3)= entity/physical entity/causal agent	finder
T(finder-sense#4)= abstraction/physical entity/physical object/whole/artifact/instrumentality/device/optical device/finder-optical device that helps a user to find the target of interest	finder

cvii. Table containing lexical hierarchy heuristics for Girju's SR BENEFICIARY for Arg_1

Likewise, WordNet lexical hierarchies for modifier noun Arg_2=reward is shown below:

T(Arg_2)=Lexical Hierarchy	Noun
T(reward-sense#1)= entity/abstract entity/abstraction/psychological feature/event/happening/conclusion/result/consequence/reward-recompense for worthy acts	reward
T(reward-sense#2)= entity/abstract entity/abstraction/relation/possession-anything owned/transferred property/loss/financial loss/expenditure/cost/payment/reward-payment made in return for a service rendered	reward
T(reward-sense#3)= entity/abstract entity/abstraction/psychological feature/event/human action/activity/aid/support/blessing/reward-act performed to strengthen approved behaviour	reward
T(reward-sense#4)=entity/abstract entity/abstraction/attribute/quality/good/benefit/reward-benefit resulting from some event	**reward**

cviii. Table containing lexical hierarchy heuristics for Girju's SR BENEFICIARY for Arg_2

Based on Designer Analysis the closest sense pair that explains **SR_{20}-BENEFICIARY** defined by the following rule:

> **SR_{20}-BENEFICIARY RULE**: Any noun compound **Arg_1+Arg_2** made up of **Arg_1** that contains this part of the simple type from WordNet: **physical entity/physical object/living thing/organism/person,** along with Arg_2 that contains this part of the simple type from WordNet: **entity/abstract entity/abstraction/attribute/quality/good/benefit,** will generate the FOR=**FOR(Beneficiary)** preposition as underlying semantic relation between both noun constituents **Arg_1** and **Arg_2**, resulting in the following pruned simple type from **Arg_2: entity/abstract entity/abstraction/attribute/quality/good/benefit**