

A Knowledge Representation for, and an Application to Requirements Elicitation of, Rhetorical Figures of Perfect Lexical Repetition

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Rhetorical figures, such as rhyme and metaphor, affect human discourse by providing essential semantic and pragmatic information that generate a set of attentional effects such as salience, aesthetic pleasure, and memorability, that enhance the receiver’s attention. Ploke is one kind of rhetorical figure, that of perfect lexical repetition, which is a word or phrase that repeats with the same form and meaning in a passage. Rhetorical figures, including pokes, are largely ignored in natural language processing (NLP) and artificial intelligence (AI). This thesis aims to take two steps towards AIs’ being able to handle pokes as they occur in natural language. It first develops a knowledge representation model of the general concept of Ploke in the form of an ontology that represents the classification of Ploke, the forms of pokes, and the neurocognitive affinities that affect attention. This ontology will help AIs to understand and generate pokes. The ontology proposed in this thesis is able to represent the related knowledge of plope and its subtypes. The ontology is able also to represent the neurocognitive affinities of plope and its subtypes by representing their relations to various types of perfect lexical repetition characterized by the positions in which the repetitions occur. After observing that rhetorical figures are used to enhance persuasive discourse, the thesis hypothesizes that a requirements elicitation interview that uses pokes is more effective than one that does not. It then describes a test of this hypothesis in which the interviews were conducted by a simulated AI elicitation bot, which used some pokes in half of its interviews and avoided pokes entirely in the other half of its interviews. The experiment showed that the interview questions and statements conveyed by the simulated AI elicitation bot in its plope-using requirements elicitation interviews were easier to recognize by the interviewees and were more memorable to them than those in its plope-avoiding requirements elicitation interviews.

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Dedication

To my dear son, Yilin.

Table of Contents

Examining Committee Membership	ii
Author's Declaration	iii
Abstract	iv
Acknowledgements	v
Dedication	vi
List of Figures	xiii
List of Tables	xvi
1 Introduction	1
1.1 Introduction to Ploke	2
1.2 Introduction to Rhetorical Figure Ontology	4
1.3 Introduction to Application	6
1.4 Research Questions and Contributions	6
1.5 Chapter Organization	7
1.6 Notational Conventions	8

2	Background	10
2.1	Rhetorical Figures	10
2.1.1	Rhetoric is Fundamental to Natural Language	10
2.1.2	Rhetorical Figures Overview	11
2.1.3	Classification of Rhetorical Figures	13
2.1.4	Form and Function Pairings	20
2.1.5	Rhetorical Figures and Neurocognition	21
2.2	Rhetorical Figure Applications	30
2.2.1	Rhetorical Figures and AI/NLP	30
2.2.2	Rhetorical Figure Detection	32
2.2.3	Ontology and the Semantic Web	37
2.2.4	Rhetorical Figure Ontologies	38
2.3	Requirements Elicitation	44
2.3.1	Interviews in Requirements Elicitation	45
2.3.2	Conversation Analysis and Discourse Unit	48
3	Concept of Ploke	51
3.1	The Neurocognitive Path of Rhetorical Figure	51
3.2	Ploke Overview	56
3.3	Definition and Examples	57
3.4	Form/Function Correlation of Plokes	59
3.5	Neurocognitive Affinity: Repetition and Position	65
3.5.1	Collocation and Language Independence of Ploke	66
3.5.2	Position	68
3.5.3	Repetition	69
3.6	Attentional Effects	72

4	The Ploke Ontology	75
4.1	An EER Model of the Ploke Ontology	75
4.2	The Ploke Ontology: General Level	81
4.2.1	The Neurocognitive Path in Ontological Terms	81
4.3	Rhetorical Figure Level	84
4.3.1	Rhetorical Figure	84
4.3.2	Form	84
4.3.3	Linguistic Element	85
4.3.4	Scheme	85
4.4	Ploke Level	87
4.5	Token	88
4.6	Position	89
4.6.1	Position Class	89
4.6.2	Unpatterned Position	91
4.6.3	Respective Position	91
4.6.4	Relative Position	92
4.6.5	Clause	92
4.6.6	Immediate Position	93
4.6.7	Reversed Position	94
4.6.8	Position-as integer	95
4.7	Element	96
4.8	Neurocognitive Affinity: Perfect Lexical Repetition	97
4.8.1	Overview of Perfect Lexical Repetition in Ploke	97
4.8.2	Repetition	106
4.8.3	Single Repetition	107
4.8.4	Nested Repetition	109
4.9	Examples	118
4.10	Summary	126

5	Applications	128
5.1	Ploke Instances in ARM	128
5.2	An Unified Multilingual Ontology	134
5.2.1	Inconsistencies of the Ontologies	134
5.2.2	Model Inconsistency	136
5.2.3	Conceptual Inconsistency	137
5.2.4	Ontological Inconsistency	140
6	An Experiment in RE	142
6.1	Experiment	142
6.1.1	Research Questions and Hypotheses	143
6.1.2	Plan and Method	145
6.2	Evaluation Method and Analysis	153
6.2.1	Data	153
6.2.2	Question 1–3	153
6.2.3	Question 4	160
6.2.4	Question 5	160
6.3	Results	161
6.3.1	Datasets	161
6.3.2	Duration of Brainstorming and Prior Knowledge of the Software . .	161
6.3.3	Levels of Detail	162
6.3.4	Favorability of Impressions	164
6.3.5	Memorability	165
6.4	Discussion	166
6.4.1	Levels of Detail	166
6.4.2	Favorability of Impressions	167
6.4.3	Memorability	168
6.5	Limitations	169

6.5.1	Data Sparsity	169
6.5.2	Experiment Design	169
6.5.3	Figure Collocation	171
6.5.4	Deception	171
6.5.5	Fatigue	171
6.6	Future Work	172
6.6.1	Addressing Limitations	172
6.6.2	Incorporating Other Rhetorical Figures	173
6.6.3	Analyzing Response Time	173
6.6.4	A Talking Chatbot	173
6.6.5	Developing a Responsive AI Agent	174
6.6.6	Human Analyst	174
6.6.7	Rhetorical Figure and Final SRS	175
6.7	Summary	175
7	Conclusion and Future Work	177
7.1	Conclusion	177
7.2	Future Work	180
	References	184
	APPENDICES	204
A	Notational Conventions	205
B	List of Rhetorical Figures	207
B.1	Rhetorical Figure of Perfect Lexical Repetition	207
B.2	Other Rhetorical Figures	208

C	Full Results of the Experiment	211
C.1	Question 1 – Question 3	211
C.1.1	Frequency	211
C.1.2	Additional Scales	212
C.1.3	Categorize by PUF	215
C.2	Question 4	215
C.2.1	Frequency	215
C.3	Question 5	216
C.3.1	Additional Scales	216
D	Pilot Study	218

List of Figures

2.1	Rhetorical figure classification in <i>Rhetorica Ad Herennium</i>	14
2.2	Rhetorical figure classification by Quintilian	15
2.3	Rhetorical figure classification by Melancthon	15
2.4	Rhetorical figure classification by Melancthon, Fahnestock’s flattened version.	15
2.5	Rhetorical figure classification by Peacham	16
2.6	Typical scheme–trope classification of rhetorical figures	16
2.7	Peirce’s triadic model of signs	22
2.8	The concept of rhetorical figure in Peirce’s sign system	23
2.9	A demonstration of saliency. It is more likely for a reader to focus between the two opposite arrows since the arrows resemble the neurocognitive affinities that form an oppositional, balanced, and symmetrical structure. Adapted from Black [22].	27
2.10	The CENTER–PERIPHERY image schema	28
2.11	Famous Face and Vase drawing, adopted from Black et al. [23] Reproduced from Rubin [199].	29
2.12	Rhetorical Figure ontology, adapted from Harris et al. [106]	39
2.13	Structure of the RetFig ontology, adapted from Mladenović and Mitrović [166].	41
2.14	Anadiplosis in the Climatic Ontology, adapted from O’Reilly et al. [181]	43
3.1	The neurocognitive path of rhetorical figure. The Form branch is highlighted in red. The dashed line between Form and Function indicates that there is a correlation between them. How are they related and details of the Function branch are yet to be discovered.	52

3.2	Ontological view of plope, proposed by Harris [99] and Wang et al. [219]	57
3.3	Taxonomy of Plope, adapted from Harris et al. [106]. Note “Ploce” is an alias of Plope.	58
3.4	Reciprocal relation between <i>A</i> and <i>B</i>	62
3.5	The form of antimetabole triggers (a) a point balance structure; (b) a chiastic structure. The form of anadiplosis triggers (c) a focus point; (d) a step-wise energy flow. Modified based on [99, 100, 116].	66
3.6	The antimetabole in Example 2.1.1 resembles the opposite balance neurocognitive affinity.	68
3.7	The mesodiplosis in Example 2.1.1 pinpoints the balance neurocognitive affinity.	68
3.8	The epanalepsis in Example 2.1.1 creates boundaries at both ends to solidify the balanced structure.	69
3.9	The collocation of antimetabole, epanalepsis, and mesodiplosis in Example 2.1.1 generate the harmonized salience effect.	69
3.10	The same salience effect can still be interpreted without semantic information.	70
3.11	Perceptual foregrounding, adapted from Black et al. [23]. Modified based on Rubin [199].	73
4.1	Rhetorical Figure ontology general overview	82
4.2	Rhetorical Figure entities	84
4.3	Defined Rhetorical Figure entities	85
4.4	Defined general level entities	86
4.5	Ontological view of Plope	87
4.6	Classes and relations of Clause and Position	90
4.7	Ontological view of Repetition , a neurocognitive affinity.	99
4.8	Example of a Repetition using Example 2.1.1. More specifically, this is an example of a SingleRep which will be discussed later in this section.	100
4.9	Example of Cross-Boundary Repetition using Example 2.1.1	101
4.10	Example of Reversed Repetition using Example 2.1.1	102

4.11	Example of Gradatio Repetition using Example 3.4.10	106
4.12	SingleRep and NestedRep	109
4.13	Tree diagram for NestedRep	111
4.14	Subclasses of NestedRep	114
4.15	Representation 1 of abbcaddc	121
4.16	Representation 2 of abbcaddc	122
4.17	Representation 3 of abbcaddc	122
4.18	Two cases of antimetabole representation using NestedRep for abccba. . . .	124
4.19	Two representations of abccab. Only nrep2 captures an antimetabole. . .	125
4.20	Two representations of ab . . . ab. Only srep1 on the left captures an epanalepsis.	126
5.1	Classes related to Epizeuxis in the Ploke Ontology.	138
5.2	An instance of Epizeuxis in the Ploke Ontology of the phrase long, long ago. Adopted from Wang et al. [220].	138
5.3	New classes Ploke_3 and EpizeuxisG added to resolve Case 1 and 2 respectively. Adopted from Wang et al. [220].	139
6.1	Experiment process.	146
6.2	Screenshot of a Mode $\mathcal{R}$ conversation.	148
6.3	Questionnaires used in study	150
6.4	Visualization of Terms	154
D.1	Questionnaires used in study	220

List of Tables

1.1	Notational conventions of this thesis	9
5.1	Explanation of figures in different languages. Adapted from Wang et al. [220].	135
5.2	Comparison of figures of perfect lexical repetition. Adopted from Wang et al. [220].	136
5.3	Axioms of Epizeuxis in GRhOOT. Adopted from Wang et al. [220].	141
6.1	Cohen’s Kappa among datasets	162
6.2	Shapiro Wilk Test for responses of q1–q3	162
6.3	Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$	163
6.4	Shapiro Wilk Test for q4 datasets	164
6.5	q4: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$	165
6.6	Shapiro Wilk test for the original q5 dataset	166
6.7	Distinction for q5	166
6.8	Count by category in Modes $\mathcal{P}$ and $\mathcal{R}$	166
A.1	Notational Conventions of This Thesis.	206
C.1	Frequencies of each assignment in for responses to q1–q3 Mode $\mathcal{P}$ and $\mathcal{R}$.	211
C.2	Shapiro Wilk Test for responses of q1–q3 in scale-2	212
C.3	Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-2	212
C.4	Shapiro Wilk Test for responses of q1–q3 in scale-3	214

C.5	Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-3	214
C.6	Shapiro Wilk Test for responses of q1–q3 in scale-unanimous	215
C.7	Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-unanimous	215
C.8	Shapiro Wilk Test for responses of q1–q3 in scale-unanimous	216
C.9	Distinction in scores in the dataset CON categorized by questions between Mode $\mathcal{P}$ and $\mathcal{R}$	216
C.10	Count of impression score in Mode $\mathcal{P}$ and $\mathcal{R}$	217
C.11	Sample mean for dataset q5-scale-2 (None = 0, otherwise assign 1)	217
C.12	Sample mean for dataset q5-scale-NQ (None = Question = 0, otherwise assign 1)	217
D.1	Frequencies of each assignment in for responses to q1–q3 Mode $\mathcal{P}$ and $\mathcal{R}$.	218

Chapter 1

Introduction

Natural language delivers information and knowledge. Natural language is an ongoing topic of research in various fields in Computer Science such as Artificial Intelligence (AI), Natural Language (NL) Processing (NLP), Natural Language Generation (NLG), Natural Language Understanding (NLU), etc. The goal is to build an AI system that is able to retrieve and deliver information and knowledge conveyed by natural language that simulates a human in a conversation. Ideally, such an AI system would be able to interpret hidden information in a passage or utterance, such as emotion, emphasis, etc., and would be able to generate that passage or utterance in a salient, aesthetically pleasing, and memorable manner. In order to achieve this goal, the AI system must be incorporated with the ability to understand an important aspect of natural language that has been largely ignored in AI, *rhetoric*. Rhetoric focuses on not only *what* to deliver, but also *how* to deliver. In rhetoric, information is delivered using natural language, laced with devices called *rhetorical figures*. A person can be easy or difficult to converse with, a speech can inspire or bore its audience, and a literary work can be exciting or dull to its reader, depending on the presence or lack of appropriate rhetorical figures [103, 106].

Rhetoric and rhetorical figures are used in human conversations, especially when persuasion is a goal. One such conversation, occurring during software system lifecycles, is requirements elicitation, during which a requirements analyst interviews, i.e., converses with, a customer who has ideas about a piece of software in mind and wants to persuade a software engineer to build it. The analyst converses with the customer, with the aim of eliciting the requirements for the software that will end up in a specification for the software. I believe that careful use of rhetorical figures can help in requirements elicitation interviews, just as it helps in persuasion.

Suppose that we could build an AI system that understands and uses rhetoric, with the intention of deploying in situations in which humans converse with each other. Then, one use of such an AI system is as a requirements elicitation bot to help requirements analysts conduct elicitation interviews in a manner that is more engaging than otherwise. This AI system is able to recognize implicit information and knowledge delivered regarding the requirements during the conversation and is able to deliver information and knowledge more effectively by embedding rhetorical figures into the conversation. Of course, to achieve this goal completely, the AI system needs to sense information such as voice, tone or even image data. However, much of the information is carried solely by text. The conversation can be transcribed into textual data during a requirements elicitation interview. This thesis focuses on text only.

The following subsections provide an overview of this thesis. In general, the subject of the thesis is one specific kind of rhetorical figure, plope, the class of rhetorical figures of perfect lexical repetition. The thesis’s overall goal is to enhance AI systems by creating a knowledge representation (KR) model for plope and by empirically testing whether an AI that conducts requirements elicitation interviews that use plokess is more effective than one that does not.

1.1 Introduction to Plope

Rhetoric is the “ancient study of persuasion, with particular attention to the effects of expressive style on belief, action, and knowledge” [103]. The use of rhetoric affects the style and effectiveness of an utterance. As argued by Harris and Di Marco, “the meaning of an utterance is communicated through the relations among its constituents, as well as their relations with contextual and cotextual elements” [103]. Rhetoric is part of the foundation for communication. The rhetorical information embedded in style, such as lexical choice, syntactic structure; purpose, such as description, persuasion, and instruction; and affect, such as trust, comprehension, and emotion [103] are so rich and fundamental such that, in some cases, rhetorical information is able to communicate even without the analysis of syntactical information and semantics. For example, “... children learn to use rhetoric long before they learn how to put words and phrases together. A human baby’s first acts involve rhetoric: they cry when they’re hungry, they smile because it nets them attention, they fidget when they feel neglected” [118].

Devices of rhetoric called rhetorical figures generate a set of attentional effects such as salience, aesthetic pleasure, memorability and evoke communicative functions at the receiver’s side, thus managing the receiver’s attention. Common rhetorical figures, such

as *rhyme*, *metaphor*, and *sarcasm*, that are encountered in everyday conversations may be noticed easily. Other common rhetorical figures that involve traits, such as repetition, semantic increase, and inverted concepts, may not be as easily noticed. A rhetorical figure creates a “figure-and-ground landscape that focalizes some details and put others in relief” [99], e.g., communicators are attracted by the sound of the words or phrases with repeated syllables in rhymes and by the connections established between concepts in different domains when metaphors are used. As devices of rhetoric, rhetorical figures are naturally embedded in natural language and are widespread in all registers, genres, and dialects of all languages. They are linguistically inescapable and there simply does not exist a pure literal language [103, 106]. Thus, rhetorical figures are a part of the foundation of natural language and are perhaps one of the missing pieces to improve the ability to understand natural language for current Artificial Intelligence (AI) and Natural Language Processing (NLP) systems, collectively termed as “AI/NLP systems”.

However, few of even the most ubiquitous rhetorical figures have received attention in the field of computation rhetoric or AI/NLP in general. One of the most ubiquitous rhetorical figures is *Ploke*¹, rhetorical figures of perfect lexical repetition. That is, whenever a word, word string, or entire phrases or clauses is repeated verbatim, it is a plope, e.g., **long**, **long ago**; **easy come**, **easy go**; **waste not**, **want not**. These simple lexical repetitions impacts the delivery of the phrases. For example, the receiver interprets **long**, **long ago** with a longer magnitude in time than **long ago** regarding the time of the event or story of the discussion². The latter two phrases would be less salient, aesthetically pleasing, and memorable if they were written, e.g., **easy come**, **not that difficult to go** and **avoid waste**, **want not**.

A famous example of plope is the famous quote from Alexandre Dumas, **all for one, one for all** [63] that consists of multiple subtypes of Plope and other rhetorical figures. The plokies form a reversed repetition, i.e., three words repeat in a reverse order, which forms a balanced and oppositional structure that triggers a sequence of patterns called neurocognitive affinity that our mind tend to capture easily. The neurocognitive affinities triggered by the plokies and other rhetorical figures in the quote generate a harmonized attentional effect, making this quote more salient, aesthetically pleasing, and more memorable to a receiver [99, 106]. More interestingly, the form of a plope is independent of language. That is, the balanced, oppositional structure can be observed without any semantic knowledge of the language. Therefore, the attentional effects already exist in a pattern such as $\square \bigcirc \triangle, \triangle \bigcirc \square$, regardless of the meanings of the shapes. The ability

¹Also spelled as *ploce* or *ploche*. This thesis uses capitalized “Plope” for the concept of Plope and lowercase “plope” for an instance of Plope.

²This example is an instance of a subtype of plope called *epizeuxis*.

to recognize and infer about such a repetition, paired with knowledge of rhetorical figure such as its communicative function, enables the receiver to extract some information even without the need to understand the semantics of the language. For example, the phrase $\square \bigcirc \triangle, \triangle \bigcirc \square$ may convey the idea that $\square$ and $\triangle$ are equal in a way that their order is irrelevant [106]. The ability to extract information based on solely syntactical structures formed by pokes is valuable to any AI/NLP system.

1.2 Introduction to Rhetorical Figure Ontology

Current AI/NLP systems focus on superficial information based on syntactical analysis and semantics at the expense of rhetorical information. Harris and Di Marco argued that “Too much attention has been placed on semantics at the expense of rhetoric (including stylistics, pragmatics, and sentiment)” [103].

One might think that AI/NLP systems should understand the more foundational aspects of natural language such as syntax and semantics before they can move on to the more advanced aspects such as rhetoric. However, as discussed in Section 1.1, rhetoric *is* one of the foundational aspects of natural language. Rhetoric conveys critical information for understanding context and purpose, and is perhaps the missing piece needed to improve the ability of current AI/NLP systems to understand natural language. It might be that understanding rhetoric is a prerequisite for fully understanding natural language. Therefore, incorporation of rhetorical principles such as rhetorical figures in current AI/NLP systems is an important area of study.

Rhetorical figures are being investigated by various researchers in AI and linguistics using both machine learning (ML) and KR approaches³. State-of-the-art Large Language Models (LLMs) applications such as GPT-4o [178], DeepSeek [53], Gemini [211], Qwen [193], etc. are able to generate simple sentences with certain rhetorical figures, even with simple explanations using definitions of rhetorical figures. However, accuracy is not guaranteed and the difference between human and LLM-generated text is significant [196]. Also, these LLMs often struggle with generating and detecting sentences with rhetorical figures even in English, and the performance is worse in other languages [131]. In fact, these LLMs struggle with the ability to reason or infer logically [11]. Kühn and Mitrović [130] suggest that KR models such as ontologies can be combined with LLMs to enhance the context of an LLM with knowledge of rhetorical figures from the ontologies, especially

³Please see Chapter 2

in a Retrieval Augmented Generation (RAG) system [142]. This thesis helps advance the KR approach by proposing a KR model, i.e., an ontology for Ploke.

The *Rhetoricon* project⁴ [105] at the University of Waterloo is an initiative to construct an neurocognitive ontologies for rhetorical figures. An ontology is a representation of entities that organize concepts and describe relationships between them explicitly. Ontology, as part of the foundation of AI, provides an “explicit specification of a conceptualization” [89], and a description of the “concepts and relationships that can exist for an agent or a community of agents” [89].

The reason to take an ontological approach is due to the neurocognitive nature of both rhetorical figures and ontologies [106]. An ontology is neurocognitive in the sense that it not only captures **isA** and **partOf** relations among rhetorical figures, it also allows a rhetorical figure to generate potential attentional and mnemonic effects, e.g., whether a word or word group is more salient than other words or word groups in the same utterance, in order to understand rhetorical strategies embedded in an utterance [103, 106]. Multiple rhetorical figure ontologies are required for automatic figure recognition, annotation, and generation, which are critical for applications of AI/NLP systems involving rhetorical figures. Thus, a formal KR model of Ploke is valuable for any AI/NLP system. Since rhetorical figures are ubiquitous in any language, an ontology that is able to represent the neurocognitive aspects of rhetorical figures can be applied in any activity that involves pragmatics or style.

The goal of this research is to design and construct an ontology for Ploke [219] that captures linguistic features of different kinds of pokes and rhetorical figures in general and in terms of their form, their function, and their associated neurocognitive affinities that affect attention, i.e., repetition and position. A specification of this ontology can be easily adapted to aid various AI/NLP systems for various applications such as argumentation mining [86, 87, 140, 163], sentiment analysis [120], fake news and hate speech detection [36, 141, 167], text summarization [4], text improvement [103], authorship attribution [115, 207], machine translation [43], and translation with a focus on maintaining the rhythm of the source text [134]. It can also be easily reused and extended as part of a more general or a more specific ontology of rhetorical figures. Rhetorical figures have received more and more attention in the field of NLP in recent years, as their significance has become clear for the mentioned tasks.

⁴Re-branded from the former *RhetFig* project

1.3 Introduction to Application

An application of the ontology proposed in this thesis is in the area of Requirements Engineering (RE). Requirements elicitation is an important component of RE, which is the process of extracting requirements specifications from users or stakeholder, during which communication between two parties are heavily involved. Requirements elicitation usually involves an interview between an analyst and a customer. Thus, the effectiveness of communication between the analyst and the customer is crucial to the final requirements specifications, and the communication can be affected by the attentional effects of pokes and rhetorical figures in general. An example scenario⁵ [57] is that a customer wishes to discuss an app that automatically finds the lowest fuel price in an area. The customer describes his idea of the app, but cannot make a concise statement of the goal of the app. The analyst responds: “so the goal is to save money, save money on the fuel.” Although this may be unintentional by the analyst, it concisely summarizes and effectively delivers the goal of the app. The repetition of **save money**, which is a subtype of plope called *anadiplosis*, emphasizes the ultimate goal of the app. The attentional effect of the anadiplosis facilitates the effectiveness of the delivery the analyst’s statement, possibly making the goal of the app more salient and memorable to both the analyst and the customer.

This thesis also reports on an empirical study to investigate the attentional effects of certain pokes that an analyst uses during a requirements elicitation interview. The empirical study compares the effectiveness and memorability of requirements elicitation interviews of two groups of participants, one whose interviews use instances of certain pokes and the other whose interviews use no pokes at all.

1.4 Research Questions and Contributions

The research question of this thesis is two-fold:

1. Can concepts of Plope such as its classification, form, and neurocognitive affinities be represented using a KR model expressed as a combination of an Extended Entity-Relationship (EER) diagram and first-order theory?

⁵This scenario was observed from a recording of a requirements elicitation interview conducted by Donati et al. [57]

2. Can the use of pokes increase the effectiveness of a requirements elicitation interview? By “effectiveness” is meant that the interviewee ends up providing more detail about his or her requirements and remembers more of what the interviewer says.

The contributions of this thesis are the KR model and the empirical study:

1. The KR model presented in this thesis represents the classification and neurocognitive affinities of Ploke. The KR model enables the ability to infer and reason about the represented knowledge of pokes and rhetorical figures automatically, therefore, enhancing the ability of an AI/NLP system to understand rhetorical information embedded in natural language. A formal representation of the attentional effects of Ploke or of rhetorical figures in general is out of the scope of this thesis. Instead, it is an important aspect of future research that requires further research and collaboration in multiple fields such as AI, rhetorical figure, cognitive science, psychology, etc.
2. The empirical study serves as an investigation of the connection between pokes and the attentional effects they generate. Besides investigating the attentional effect of pokes, a crucial component of the neurocognitive path that is proposed in Chapter 3 of this thesis, the study contributes also to the field of Requirements Engineering by establishing the idea that the use of rhetorical figures may impact the results of the requirements elicitation process. The connection is novel to both fields of Requirements Engineering and Rhetorical Figures.

1.5 Chapter Organization

In the rest of this thesis, Chapter 2 introduces the background knowledge related to this thesis in rhetorical figure, requirements elicitation, and knowledge representation. Chapter 3 proposes the neurocognitive path of a rhetorical figure, which is a general conceptual model of concepts and their connections in rhetorical-figure-ontology research. It then discusses specific components of concepts related to pokes in detail, but in an informal manner, before presenting of the formal ontology in Chapter 4. Chapter 4 describes the Ploke Ontology, a formal ontological representation of concepts of Ploke presented in Chapter 3. This chapter discusses in detail the classification and description of pokes and related knowledge such as form, linguistic features such as tokens involved in a pokes, and neurocognitive affinities including various types of perfect lexical repetitions based on positions, differing in the

positions of the repeated elements. The Ploke Ontology is represented using the Extended Entity-Relationship (EER) model and First-Order Logic (FOL) formulas. Chapter 5 discusses extensions of the Ploke Ontology. Chapter 6 discusses an application of Ploke in RE and presents an empirical experiment of attentional effects generated by pokes in the settings of a requirements elicitation interview. Chapter 7 concludes this thesis and describes potential future research directions and applications that could be developed based on this research.

1.6 Notational Conventions

Table 1.1 summarizes the notational conventions for all the kinds of text that appear in this thesis. This table appears also as Appendix A for easy reference throughout the reading of the thesis.

Text Type	Convention	Example
Regular text	Roman	-
Headers	Boldfaced	-
Introduction of terms	<i>Italics</i>	<i>ploke</i>
Mathematical formula	Standard mathematical notation	$A \wedge B$
Quotations other than examples	Each quotation is surrounded by quotation marks.	“some quotes”
Examples	Example texts are in Typewriter font.	all for one; all
Single character examples	Examples with only one character are surrounded by single quotation marks.	‘a’, ‘b’, ‘c’
Class names in ontologies	Each class name is in Sans serif with the first letter capitalized.	Ploke
Relation names in ontologies	Each relation name is in Sans serif with the first letter not capitalized.	for(all,one)
Relation parameters of type example	A parameter of type example is in slanted <i>Typewriter</i> font.	for(<i>X,Y</i>)
Relation parameters of type class	A parameter of type class is in slanted <i>Sans serif</i> font.	for(<i>X,Y</i>)
Noteworthy repetitions in pokes	Occasionally, each occurrence of a repeated phrase in an example is <u>underlined</u> .	<u>easy</u> come, <u>easy</u> go.
Entity sets and table names	Entity sets and table names are in uppercase Typewriter	LABEL

Table 1.1: Notational conventions of this thesis

Chapter 2

Background

2.1 Rhetorical Figures

2.1.1 Rhetoric is Fundamental to Natural Language

Rhetoric is the “ancient study of persuasion, with particular attention to the effects of expressive style on belief, action, and knowledge” [103]. The study of rhetoric started as early as the 5th century B.C. by Corax and Tisias [189] and Sophists such as Georgias and Isocrates when there were great needs of education on rhetoric to serve the purpose of argumentation and persuasion among the ancient Greek city-states. Rhetoric was then examined by scholars like Plato, who believes the means of persuasion is grounded in logic. Plato’s student, Aristotle, defined rhetoric as “the faculty of observing in a given case the available means of [p]ersuasion” [9] and introduced the Rhetorical Triangle: logos, the appeal to logic and reason; pathos, the appeal to emotion; and ethos, the appeal to the character of the communicator [9]. Cicero and Quintilian later categorized rhetorical practice into five canons: inventio (invention), dispositio (arrangement), elocutio (style), memoria (memory), and actio (delivery) [41, 55, 192]. As summarized by Harris and Di Marco [103], the canon of style studies attributes of a passage or speech such as the lexical choice, or syntactic structure; purpose, such as description, persuasion, and instruction; and affect, such as trust, deference, and emotion. The rhetorical information embedded in these attributes is so rich and fundamental that, in some cases, they are able to communicate even without syntactical information and semantics. For example, infants use rhetorical actions to communicate effectively before they can speak. These actions include screaming, repetition of single syllable, and body language [118]. As a foundational

building-stone of natural language, rhetoric still plays an important role after a human learns to use words and phrases in which it affects the delivery of information carried by the words and phrases through cognition.

Rhetoric deals with cognition which makes the information delivered more influential and effective. Smith observes that “rhetoric is intrinsic to our existence as it deals with our emotional and psychological states” [77, 205]. Hosman states that variations of elements of language such as phonology, syntax, lexicon, and text or narrative all have impact on aspects of communication such as judgment of the speaker, message comprehension or recall, or attitude toward the message [111]. This thesis focuses on a stylistic device of rhetoric called rhetorical figure.

2.1.2 Rhetorical Figures Overview

A rhetorical figure is a device of rhetoric that generates a set of attentional effects such as salience, aesthetic pleasure, and mnemonic effect received by the audience, thus managing the receiver’s attention. Rhetorical figures such as rhyme and metaphor are well studied and commonly used in daily conversations. Rhyme is the proximal repetition of syllables that exists vastly in poems, jingles, and doxa, etc. In addition to factors of salience, rhyme also creates a conceptual amalgamation and a receiver judges expressions to be truer and more accurate when rhyme is used [96, 151]. Metaphor makes analogy between instances from two different domains in a way that the similitude between the referred instances are easily captured by the audience. Metaphors are well studied for their use both in specialized discourse, such as poetry and oratory, and in daily conversations. An empirical study conducted by Sopory and Dillard demonstrated that messages tend to be more persuasive when metaphors are used [206]. Other studies have shown that metaphorical messages are processed differently at neurological level [27, 32].

Other common examples of rhetorical figures include irony, sarcasm, rhetorical question, etc. There are countless other rhetorical figures that are commonly used in daily conversations but are not recognized by the speaker. An example is the dead metaphor such as the “arm” of chair in which the term “arm” has been widely accepted to be associated with the object chair other than its original definition as a body part [99]. Another common example is the figure plope, which is characterized by perfect lexical repetitions (both the form and semantics remain the same) of a word or phrase, and repetition is ubiquitous in any language. Thus, a rhetorical figure (also rhetoric in general) is not a more advanced feature but a natural component of natural language. Rhetorical figure deals with the third canon of rhetoric, i.e., *elocutio*, which is the aspect of style. *Elocutio* is the

“process of how you present your arguments using figure[s] of speech and other rhetorical aspects” [155]. Thus a rhetorical figure is a device that directly impacts the delivery of content and context during communication.

As a device of rhetoric, the study of rhetorical figures also dates back to the time of Aristotle and has flourished under classical scholars like Cicero [40, 41] and Quintilian [192], early modern scholars such as Sherry [203] and Peacham [183], and contemporary researchers like Burke [33], Fahnestock [67] and Harris [103, 106], etc. The study of rhetorical figures once dominated the study of rhetoric such that it was reduced to the study of elocution, “the study of ornate forms of language,” and, from that, the study of figures [187, 215]. As noted by Madison [147],

Petrus Ramus (Pierre de la Ramee [1515–1572]) whose work emphasizes “logical analysis” and “plain (mathematical) style” and paves the way for Cartesianism, severs dialectic (“the art of reasoning well”) from rhetoric and moves it to the side of logic or analytics, thereby divesting rhetoric of its traditionally recognized, all important functions of *inventio* ... *dispositio* ... leaving it only with the “decorative” functions of *elocutio* and *ornare* or *ornamentum* (*figurae*) ... [147]

Perelman remarks that the innovation of Ramus: “turned out to be an error that was fatal for rhetoric ... In this way classical rhetoric came into being—this rhetoric of figures which led progressively from the degeneration to the death of rhetoric” [147, 187]. Perelman proposes *New Rhetoric*, which attempts to bring rhetoric back to attention by “first insisting upon the importance of rhetoric in reasoning, in which figures play an important role” [215].

Rhetorical figures are not merely about style and ornament of natural language [103]. The use of rhetorical figures affects the delivery in natural language such as argumentation and persuasion. As discussed in later sections, rhetorical figures are cognitive and are able to “epitomize fundamental mental operations” [67]. As stated by Fahnestock, “[figures] are typically used in the process of conveying the core of an argument in research articles and in versions of these articles constructed for wider audiences” [69]. Therefore, rhetorical figures are an inseparable aspect of natural language that can create significant impact between communicators whether intentional or unintentional.

Rhetorical figures are linguistically inescapable and ubiquitous in natural language. Rhetorical figures occur as ordinary language in both formal and informal situations and are an intrinsic part of language. They “do not belong in a separate domain of language

use but are rather on a continuum of constructions that are successful in varying degrees as epitomes of their functions” [67, 106]. Since rhetoric is a fundamental aspect of natural language, it is also the case for rhetorical figures. There is no plain or zero-degree language¹. Rhetorical figures are “omnipresent in language, communicating intentions and desires, coding information and attitudes, propagating belief and knowledge” [106]. There will always be a rhetorical figure in a given passage as shown in the cases of plover and dead metaphors. A trained rhetorician or linguist is likely to recognize more figures than someone without the knowledge, but the figure is there. It is also possible to invent new figures since rhetorical figures evolve with natural language.

Different definitions and classification methods of rhetorical figures have been proposed over the thousands of years of rhetorical figure study. The classification of rhetorical figures is itself a topic of discussion, which is illustrated in the next section.

2.1.3 Classification of Rhetorical Figures

As different names and definitions of rhetorical figures exist, a classification can never be unambiguous against the background of the inherited terminology. The classification of rhetorical figures has undergone various arrangements to better understand and appreciate their qualities [28]. Traditionally, rhetoricians classify rhetorical figures into figures of speech and figures of thought, where the former is characterized by verbal expression and the latter by the expression of ideas. Fahnestock [67] provides an excellent overview of the development of rhetorical figure classification by reviewing the taxonomies from the ancient text of *Rhetorica Ad Herennium*, to early modern classification schemes proposed in the Renaissance era. In *Rhetorica Ad Herennium*, the earliest record on classification of figures, the unknown author, mistakenly attributed to Cicero [35], categorized three types of figures: figure of diction (words) [*exornationes verborum*], figure of thought [*exornationes sententiarum*] and trope.

It is a figure of diction if the adornment is comprised of in the fine polish of the language itself. A figure of thought derives a certain distinction from the idea, not from words [35, p.275][67].

Although only the first two categories were identified explicitly, a distinction was made for a subgroup of figures under figures of diction including metaphor, metonymy, hyperbole, etc. which are later classified under the trope category [35, 67].

¹Linguists such as Sopory and Dillard [206], and Giora [79] may use the term *literal language* to distinguish between metaphorical and non-metaphorical language. But it does not mean that there are no rhetorical figures such as schemes in “literal language”.

There remain also ten Figures of Diction, which I have intentionally not scattered at random, but have separated from those above, because they all belong in one class. They indeed all have this in common, that the language departs from the ordinary meaning of the words and is, with a certain grace, applied in another sense [35, 67].

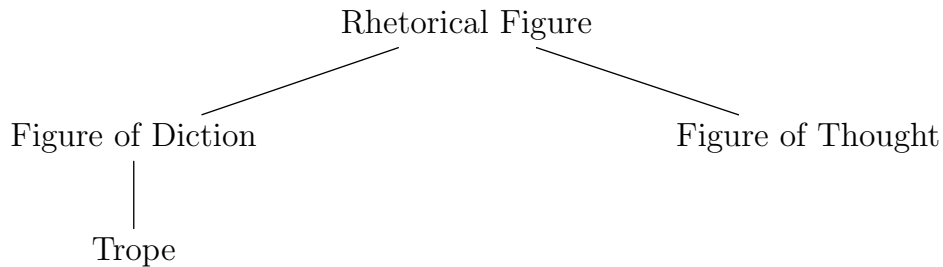


Figure 2.1: Rhetorical figure classification in *Rhetorica Ad Herennium*

Fahnestock then described the inconsistencies of this classification:

... each of three groups of figures in the *Ad Herennium* hardly seem to fit the principles that apparently produced the categories in the first place ... but within these three divisions it uses no consistent principles of sorting. Though most of the *exornationes verborum* [figure of diction] can be defined linguistically and most of the *exornationes sententiarum* [figure of thought] can be defined by purpose or effect, there are devices in each of the two divisions that defy this distinction [67].

Two hundred years later, in the books of his *Institutio Oratoria*, Quintilian [192] made an important change to the hierarchical relationship of rhetorical figures proposed in the *Ad Herennium*. He distinguished tropes from what was termed as “figure”. Then classified “figure” into figure of thought and figure of speech following *Ad Herennium*. What Quintilian called a “figure” is later referred to as “scheme”. Therefore a major distinction was made between trope and scheme by Quintilian. However, a subtype of what Quintilian called a “figure” (scheme), figure of thought, in which resembles the later concept of speech-act, becomes easily ignored [67].

Philip Melanchthon [157] advised a different partition of trope and scheme, in which scheme is classified as three categories instead of two as Cicero’s *De oratore* [40] and Quintilian’s *Institutio Oratoria*: figures of grammars and words, which deals with the

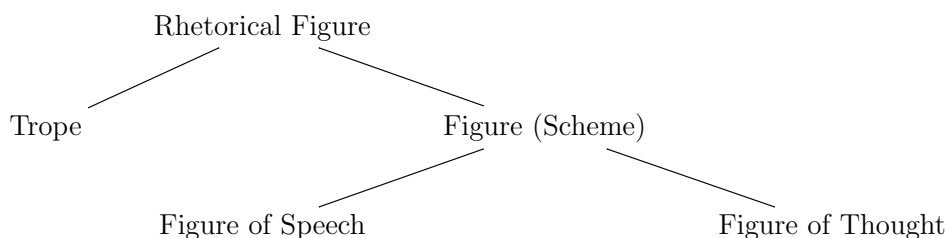


Figure 2.2: Rhetorical figure classification by Quintilian

“position of words or emphasis and clearness of the nouns”; figures of thought, which deals with “thought or idea . . . that give action to speech such as interrogation . . .”; and a new set of figures of amplification, which “comprises of enlarging . . . which embellish the speech and make it broader and more extended”. Fahnestock then suggests that it is possible to flatten the four-part categories and use the name *scheme* for figures of grammars and word, figures of speech act or interaction for figures of thought [67].

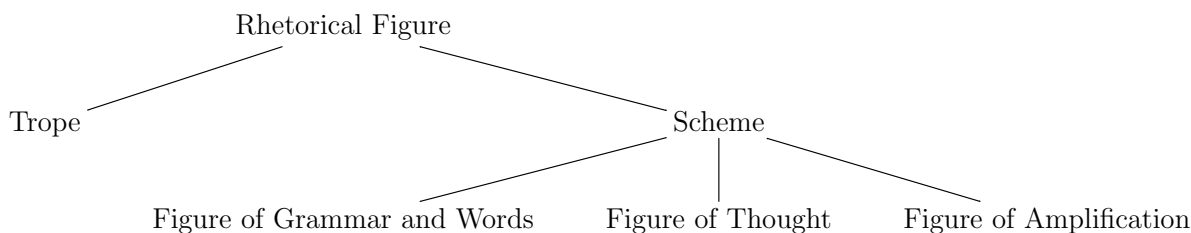


Figure 2.3: Rhetorical figure classification by Melancthon

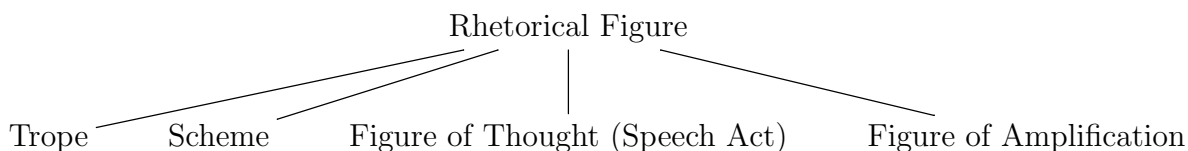


Figure 2.4: Rhetorical figure classification by Melancthon, Fahnestock’s flattened version.

Peacham [183] maintains trope and scheme with subdivisions for both. Trope was further classified by the size of the unit affected. Scheme was further classified into three orders: figure of words, figure of affections, and figure of amplification. Peacham [183] then further divided the three orders of scheme into subcategories. Figure of words by operations: repetition, omission, conjunction, separation. Figure of affections by effects

the speaker wants to have: exclaiming, moderating, consulting, conceding or submitting to judgment. Figure of amplification by distribution or spreading of the content, etc.

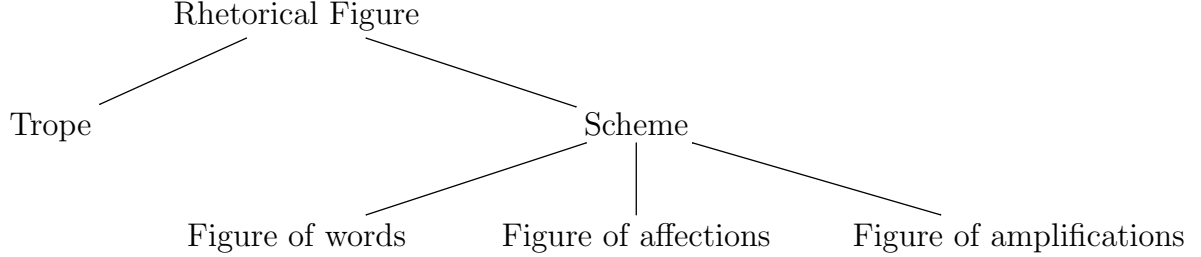


Figure 2.5: Rhetorical figure classification by Peacham

Rhetorical figures can also be classified using a number of methods that emphasize various aspects. For example, rhetorical figures can be grouped by strategy or rhetorical operations: amplification, grammar, addition, omission, repetition, transposition, permutation, etc. [34] Other classifications methods have also been attempted and discussed by linguists such as Bradley [28], Burke [33], Meyer [159], etc.

Despite the inconsistencies of various classifications of rhetorical figure, the most simple and traditional categories of scheme and trope remain dominant. It is commonly accepted to classify rhetorical figures into schemes and tropes nowadays. However, further categorization of rhetorical figures is still under a long term debate. For example, as mentioned, figures under the traditional category of figure of thought such as a rhetorical question, sarcasm, etc. are easily ignored [67]. A taxonomy proposed by Chien and Harris [39] has two additional classes, i.e., chroma and move, which are introduced to represent the class of rhetorical figures related to a speaker’s intent. For the purpose of this thesis, I adopt the most simple classification of rhetorical figures: scheme and trope. As illustrated in Figure 2.6, a rhetorical figure can be categorized into classes of schemes and tropes, which are based on forms and semantics of text respectively.

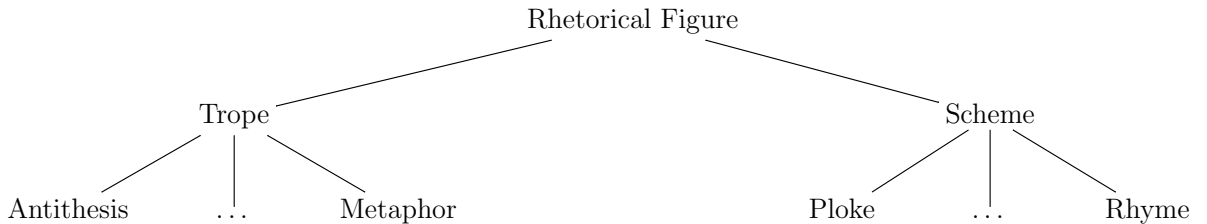


Figure 2.6: Typical scheme–trope classification of rhetorical figures

A *scheme* is a general class of figures that is characterized by form such as phonology, morphology, lexis, and syntax. A scheme can be formed by, for instance, an effective repetition or alternation of position of a word or phrase in a passage. A *trope* is another general class of figures that is characterized by the semantics within the passage. Examples of scheme and trope are demonstrated below, starting with a famous scheme:

all for one, one for all. [63] (Example 2.1.1)

In Example 2.1.1, words are repeated but in reversed order. Example 2.1.1 is a scheme since it is characterized by the reversal and repetition of the words **all**, **for** and **one**. This is a figure called *antimetabole*². Rhyme is also a subclass of scheme since its form is characterized by the repetition of word-ending syllables. Schemes are “formal in nature, and their conceptual operation is secondary to their structural arrangement” [103]. As shown in the following examples of scheme, the semantics of those words are irrelevant. The following definitions are adapted from Harris and Di Marco [104].

Alliteration: consecutive use of words with the same initial consonants.

Peter Piper picked a peck.

Anadiplosis: the repetition of a lexeme or lexical groups on either side of a clause or phrase boundary.

All for one, one for all.

Antimetabole: the proximal occurrence of the same two lexemes or lexical groups in reverse orders.

All for one, one for all.

Epanaphora: the occurrence of the same lexeme or lexical group at the beginning of proximal clauses or phrases.

That’s one small step for man, one giant leap for mankind. [12]

²There are multiple figures in this passage as explained later.

Isocolon: the proximal repetition of the same prosodic contours, such as same syllable count or length.

Veni, vidi, vici (I came, I saw, I conquered).

Parison: the proximal repetition of the same syntactic pattern [96].

All for one, one for all.
 $[N[P[N]_{NP}]_{PP}]_{NP}[N[P[N]_{NP}]_{PP}]_{NP}$

Polyptoton: the use of one word stem in a variety of morphological instantiations.

That team is the suckinigest bunch of sucks that ever sucked

Ploke/Ploce/Ploche: the occurrence of the same lexeme or lexical group two or more times proximally³.

The focus of this thesis is on a subcategory of scheme, the figures of perfect lexical repetition. This subcategory includes ploke, antimetabole, epanaphora, etc. and is discussed in detail in Chapter 3 and on.

The following famous quote from Neil Armstrong [12] is an example of trope:

That's one small step for man,
 one giant leap for mankind.[12] (Example 2.1.2)

Example 2.1.2 is a figure called *antithesis* formed by the semantic opposition of the words **small** and **giant**. The figure antithesis is a subtype of trope as illustrated in Figure 2.6. Trope figures are the focus of most studies on rhetorical figures [99]. Metaphor is also a trope, in fact, it is the most ubiquitous trope that is so well-adapted in daily conversations such as that communicators may not recognize them anymore, such as the dead metaphor example (the *arm* of a chair) given previously. Metaphors rely on the cognitive principle of comparison. In contrast with scheme, the “form a trope takes is secondary to the conceptual principles at work. If there is no expression of comparison, there is no metaphor” [103]. For example, Harris and Di Marco discussed the comparison of two concepts in different domains in the instance of metaphor “Jeff is a brick” which compares Jeff in the people domain to the brick in the object domain in terms of solidity.

³This is the traditional definition. This thesis defines ploke differently in Chapters 3 and 4.

We can say *A brick, that's Jeff*. We can say, *Jeff is the brick of that family*. And so on, in as many syntactico-lexical configurations as we have the imagination, and we still have a metaphor. But, if we say, *Jeff is a stable guy*, the metaphor is gone (strictly speaking, of course, we bring in another metaphor, since *stable* is fundamentally a physical term, and here we are using it for emotional and social purposes, but it is a subtler, more ‘literal’ sort of metaphor) [103].

Synecdoche is another trope which uses a part of the concept or object to represent the whole, e.g., the phrase **All hands on deck** identifies sailors with **hands**, the aspects of their anatomy critical for their sailorly tasks [103].

Note that these examples often consist of multiple rhetorical figures. [Example 2.1.1](#) consists a number of different types of scheme such as anadiplosis, antimetabole, parison, etc. as shown above. [Example 2.1.2](#) also contains figures epanaphora (repetition of words in the beginning of proximal clauses, i.e., **one**), parison (the repetition of syntactic structure, i.e., $[[Adj][Adj][N][[P][N]]_{PP}]_{NP}$), polyptoton (**man** and **mankind**), and metaphor (the abstraction of **man** and **mankind** cannot **step** nor **leap**). Rhetorical figures often work together to maximize cognitive appeal and constrain the range of rhetorical functions [96]. This property is referred as the multiplicity or collocation of rhetorical figures [106, 215].

The simple scheme and trope classification is only a high level classification. The various methods of identifying subcategories of rhetorical figures were demonstrated in this section. Fahnestock points out that the problem with the classification systems is the inconsistencies among the different classifications. It is difficult to see why the figures are classified in one way rather than another and cannot appear in two categories. Fahnestock gives an example using antithesis, which can be classified as both a figure of diction and a figure of thought in *Rhetorica Ad Herennium*, a figure of diction in Quintilian’s classification, and a figure of amplification in Melancthon’s classification [67]. Harris classifies antithesis not only as a trope, but it should be one of the Four Master Tropes⁴ [97]. Fahnestock argues that the inconsistencies of classification is due to that all authors are trying to organize figures by “codifying two different things: verbal forms and discourse function or speech acts” [67]. Many classifications are based on form, e.g., figure of sounds, repetition, etc., while some are based on functions or purposes, e.g., figure of amplification, exclamation, submission to judgment, etc. She proposes a view of rhetorical figures as form and function pairings which will be discussed in Section 2.1.4.

⁴Traditionally, rhetoricians named metaphor, metonymy, synecdoche, and irony as the Four Master Tropes. Harris argues that irony should be replaced by antithesis. Readers who are interested can refer to Harris [97] for further information.

2.1.4 Form and Function Pairings

A rhetorical figure is an amalgamated form and function⁵ with both aesthetic and communicative effects. The form is the tractable portion and the syntactic representation of a rhetorical figure. The form of a rhetorical figure consists of linguistic elements such as words, phrases, syllables, syntactical structures, etc. Rhetorical figures serve (rhetorical) functions. A function is the pragmatic, argumentative, and communicative action of a figure. The function gives a figure its rhetorical purpose [96]. Both the aesthetic and the communicative effects of figures are frequently enhanced by the other figures they collate with. Some examples of rhetorical function includes reciprocity, irrelevance of order, rejection-replacement, comprehensiveness, stability of reference, binary, signal paradox, reversal, singular effects, mutual exclusivity, etc. The function becomes highly predictable when the form of a rhetorical figure is recognized [106]. Jeanne Fahnestock, in her book *Rhetorical Figures in Science*, articulated her Figural-Logic view on rhetorical figures as constructions with especially tight couplings of form and function [107]. Fahnestock argues that figures “map function onto form or perfectly epitomize certain patterns of thought or argument” [140]. The idea of viewing rhetorical figures as form/function pairing was largely forgotten in modern rhetoric. Fahnestock reinvigorates this view based on previous scholars such as Aristotle [9], Perelman and Olbrechts-Tyteca [186, 188], and Turner [121]. The view of rhetorical figures as form/function pairings has been adopted and supported by contemporary researchers such as Tindale [213] and Harris [92], and have been applied in areas such as argumentation [140].

Recall the example of rhyme. The form of rhyme is the proximal word-final syllable repetition in separate words. The function of rhyme is the conceptual amalgamation which makes concepts carried by the rhyming terms seem like they belong together [96, 151]. Another example is the function of figures such as antimetabole, in which the reversed repetition of words or phrases (i.e. the form) stabilizes reference and establishes relations such as reciprocity (i.e. the function). The form of an antimetabole such as [Example 2.1.1](#) can be represented as:

$$\dots A \dots B \dots B \dots A \dots$$

where A and B are words or phrases being repeated, i.e., $A = \text{all}$ and $B = \text{one}$, and an ellipsis is any intervening material, possibly null. An antimetabole in this form functions to convey the reciprocal relationship between the concepts carried by $A = \text{all}$

⁵Also referred to as *rhetorical function*.

and $B = \text{one}$ [67]. There are various functions depending on the specific word or phrase used in an antimetabole [95, 100, 102], and the figures it collates with. A more detailed discussion is in Chapter 3.

The link between the coupling of form and function is neurocognition. It is the neurocognitive processes that generate attentional effects that make the difference when a rhetorical figure impacts the delivery of the passage or utterance to a receiver. Function is certainly one of the influential factors to the generation of the attentional effects. However, it is more difficult to track and needs more investigation and research to reveal its connection to the neurocognitive process of rhetorical figures. Harris has made a significant step forward in his recent work to demonstrate the connections between the rhetorical functions and neurocognition [100, 102]. The focus of this thesis is on modeling the neurocognitive process of the generation of attentional effects through the form of rhetorical figures.

2.1.5 Rhetorical Figures and Neurocognition

It is not difficult to realize that some passages are more recognizable and memorable than others. Rhetorical figures play an important role in generating such attentional effects. The attentional effects of a trope figure such as a metaphor have been widely studied and recognized [206]. However, the attentional effects are universal to all rhetorical figures, thus scheme figures exhibit similar effects. For example, proverbs such as “A penny saved is a penny earned” and “An apple a day keeps the doctor away” consist of figures such as rhyme, epanaphora, parison, and isocolon. These proverbial colligations are salient, mnemonically resilient, and embedded in our cultural habits of thought [23]. As stated by Harris [99, 219], the stylistic effects of figurative language are partially explained by:

1. Semiosis, the relevance of signantia and signata for the basic scheme/trope distinction;
2. Linguistics, the elements focalized by the figure such as syllables, and words, for instance; and
3. Cognitive neuroscience, the appeal to pattern biases like repetition and similitude

Semiotics is the study of signs, and language is a system of signs [200]. In that sense linguistics is a specialization of semiotics. Rhetorical figure is inevitably related to signs and their meanings. Semiotics has been studied since Aristotle. The two most prominent systems of semiotics adopted by modern researchers were introduced by Saussure and

Peirce independently. Saussure’s system is based on the pair of signifier (signans) and signified (signatum). The signifier refers to the form of the sign while the signified refers to the concept or object. In Peirce’s system a third element is introduced which refers to the interpretation of the sign. An example to demonstrate Peirce’s system is a street light. For instance, a red light is the representamen or signifier/signans, the act of cars stopping is the object or signified/signatum, and the idea that a red light is a command for vehicles to stop is the interpretant [29]. The notion of signans and signatum is fundamental to rhetorical figures and its linguistic elements. For example, the classification of scheme and trope resembles this representation. “[S]chemes, operating on the signans plane, and tropes, operating on the signatum plane, are prototypical classes of rhetorical figures” [99].

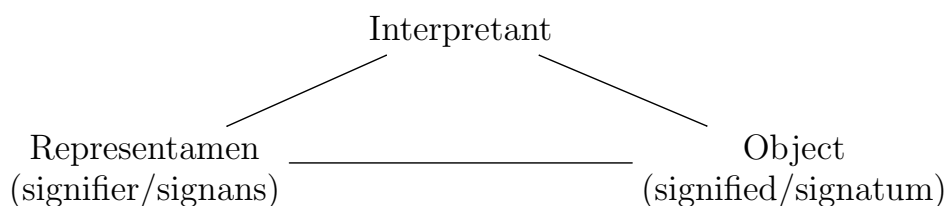


Figure 2.7: Peirce’s triadic model of signs

Peirce does not have a theory on rhetorical figures nor style directly. However, Black et al. argues that there is much room in his work that can incorporate rhetorical figures into his general semiotic theory. In particular, although Peirce’s work predates the study of cognitive science, his thought is “very consonant with cognitive approaches to meaning” [23]. For instance, Peirce argues that,

[O]ne ought to build a theory of meaning upon the immediate base of a profound study of human physiology and psychology. One ought to know just what the processes are whereby an idea can be conveyed to a human mind and become embedded in its habits; and / according to this doctrine, all the rules of ordinary rhetoric ought to be hinged upon such considerations and not upon the gratuitous assumption that men can only think according to a certain syntax-type of sentence that happens to be very common in the languages most familiar to most of us, but into which other sentences can be jammed only by Procrustean barbarities [185, p.155].

An aspect that affects the way meanings and ideas are conveyed from human mind to human mind through natural language, and become embedded in individual psychological

and cultural regimes of thought, is the attentional effects generated by rhetorical figures. These attentional effects such as salience and mnemonic resilience are not meaning. They are “matters most directly of the representamen; meaning is most directly a matter of the interpretant. The representamens aid the formation of the habits of thought, but the thought only happens because of the interpretants with which they are amalgamated” [23]. The amalgamation of representamens and interpretants of a rhetorical figure (see Figure 2.8), especially a scheme, resembles what Peirce called diagrammatic iconicity [23, 100]. In simpler words, it’s possible to view the form of a rhetorical figure as a diagram.

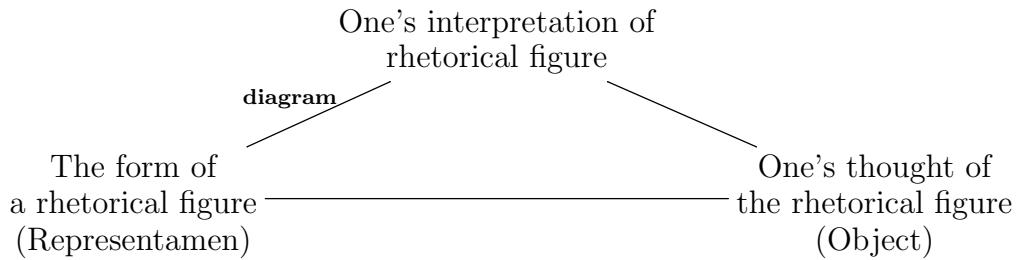


Figure 2.8: The concept of rhetorical figure in Peirce’s sign system

Peirce uses algebra and predicate calculus as representations for diagrammatic iconicity, which refine meaning down to variables, positions, and operators [100]. He states that: “an algebraic formula is an icon . . . rendered such by the rules of commutation, association, and distribution of the symbols” [184, p.105]. The common formulation of the commutative law is given below. Similar to Example 2.1.1, the commutative law consists of collocation of anadiplosis, mesodiplosis, and antimetabole among other rhetorical figures.

$$\text{Commutative Law: } a + b = b + a$$

The commutative law conveys the idea of irrelevance of order, which is also one of the rhetorical functions of antimetabole. It also conveys the idea of ideological similarity or equality through proximity, which is one of the rhetorical functions of anadiplosis. As noted by Black et al., “[t]he form itself is the meaning of these rules: the commutation rule says order doesn’t matter . . .” [23].

Another example is syllogism: “All M is P, S is M, therefore S is P”, which can be interpreted as a diagram of the relations of *S*, *M*, and *P*. “The fact that the M term occurs in the two premises is actually exhibited, and this must be done, or the notation will be of no value” [23, 184]. The figure anadiplosis becomes clear by expressing a hypothetical syllogism using the same terms and reorder the premises in propositional logic.

$$((S \rightarrow \underline{M}) \wedge (\underline{M} \rightarrow P)) \rightarrow (S \rightarrow P)$$

It is clear that, as Peirce states: “algebra is but a sort of diagram”, and “language is but a kind of algebra” [184]. Harris states that “[r]hetorical schemes are form/meaning pairs, which diagrammatically evoke conceptual understandings. The schemic form enacts the schemic meaning” [100]. Rhetorical figure therefore connects natural language between the linguistics domain to the spatial and visual domain.

Linguistically, rhetorical figures are formed by linguistic elements such as words, phrases, clauses, etc. These linguistic elements can form certain patterns that are spatial and visual [23].

It is easy, when looking at words on a page, the way you are doing now, to conceptualize language itself as spatial and visual. There are letters, with spaces between them to signal words, and punctuation to signal phrases and sentences. In a very real sense, figures and the language that instantiates them, are spatial and visual [23].

These spatial and visual patterns trigger a phenomenon called neurocognitive affinity, which is a set of patterns easily recognized by human minds. Neurocognitive affinities such as balance, repetition, similarity, and difference, which influence aspects of cognition such as attention, the ability to learn, recall, etc. [106] Rhetorical figures generate attentional effects such as salience (attention), mnemonic (memorability) and aesthetic (pleasure) effects that interact with the human mind through neurocognitive affinities, and these neurocognitive affinities are ubiquitous in natural language. Patterns in words and sentences created by phonemes, morphemes, syllables, prosodies, and semantics can be easily captured by a receiver since human minds are wired to capture these neurocognitive affinities as discussed by Harris et al. [106] below.

The machinery of argumentation specifically, persuasion generally, is guided by the organizational principles and natural affinities of the human mind. No one disputes this for analogy and metaphor, research into which goes back decades in cognitive science, but it is demonstrably true for a wide range of other rhetorical patterns. We know, for instance, that words aid in the recall of certain other words, those which share some of their phonological, morphological, or semantic characteristics (if you hear “key” you more readily call up words like “cue” “keystone” or “door”). Lexical priming, the phenomenon is

called, and it is often described as a “spreading activation” among related words in neural net models. We know, too, that the brain is particularly attuned to sounds of similar duration and frequency. We know that repetition is critically important for fixing sequences in memory (one repeats a phone number or an address to remember it). All of these brainfunction facts are reflected in the schemes and tropes of rhetorical theory [106].

In his book *Rhetoric of Motive*, Kenneth Burke [33] provides an example of antithesis to demonstrate what he calls “formal assent”.

[I]magine a passage built about a set of oppositions (“we do this, but they on the other hand do that; we stay here; but they go there; we look up, but they look down,” etc.) Once you grasp the trend of the form, it invites participation regardless of the subject matter. Formally, you will find yourself swinging along with the succession of antitheses, even though you may not agree with the proposition that is being presented in this form. . . . Thus, you are drawn to the form, not in your capacity as a partisan, but because of some “universal” appeal in it [33].

As Burke suggests, the antitheses in the quote generate an effect of cognitive inclination (swinging along) linguistically. As these antitheses are all of semantically vacant phrases, this cognitive inclination is not caused by only the antithesis but also other scheme figures such as alliteration, assonance (repetition of vowels), epanaphora, mesodiplosis, parison and isocolon [93, 215]. It’s the collocation of these figures working together that enhances the formal assent effect.

. . . a yielding to the form prepares for assent to the matter identified with it. You might have no interest in that associated matter. You may even reject it. But on the level of purely formal assent you would collaborate to round out its symmetry by spontaneously willing its completion and perfection as an utterance. . . . assent on the formal level invites assent to the proposition as doctrine [33, 215].

Cognitively, this notion of formal assent is the harmonic effect created by the neurocognitive affinities triggered by the form of the scheme figures involved. The repetitions of sound, prosody, words, and syntactical structure introduce familiarity to receivers such

that the “swinging along” effect enables them to follow along and predict the next element. Neural firing patterns can be reused under “sufficiently similar circumstances” [88]. Fahnestock [70] reports that “psychologists have recorded quicker recognition time[s] for highly constrained, predictable sentences”, which empirically confirms what Burke calls collaborative expectancy [33, 215]. As discussed by Harris, “[t]he jingle, in short, insinuates itself into your consciousness by exploiting the submerged processes from which your consciousness emanates” [106].

Functionally, formal assent is a generalized notion of conceptual amalgamation. Recall previous example of rhyme, the function of rhyme is conceptual amalgamation of the rhyming terms and the concepts delivered by these terms. People routinely perceive rhyming statements to be more accurate and more trustworthy than non-rhyming paraphrases, known as the “rhyme as reason effect”, which is a subtype of formal assent [96, 215]. Interestingly, the seminal paper on the empirical study on this effect is titled “Birds of a feather flock conjointly”, which removes the rhyming term “together” from the doxa [96, 151, 215]. Harris explains that the neurocognitive cause of the “rhyme as reason effect” is the sublexical repetitions possessed in rhymes.

[R]hyme is a staple of proverbs, heuristics, slogans, jingles, and other speech genres effecting salience, recall, propagation and aesthetic pleasure. It is a sublexical repetition, and repetition is the very substance of neurological activity (firing patterns repeat or we couldn’t even call them patterns) and a staple of cognition (if we want to remember some minor fact, we repeat it over to ourselves, lighting up the same neural pathways over and over till a trace of that fact is burned into our memories) [96].

Repetition is a crucial neurocognitive affinity that is ubiquitous in all aspects. The attentional effects are generated by rhyme because the form of rhyme triggers neurocognitive affinities such as repetition (of syllable) and similarity (of concepts). Example 2.1.1 exhibits repetition (of words) and a symmetrical structure [99]. The focus of this thesis deals with a subset of rhetorical figures of perfect lexical repetition. On the trope side, metaphor, for example, triggers the neurocognitive affinity of similitude (of concepts), Example 2.1.2 establishes contrast (between **small** and **giant**). Thus a passage with such figures are more salient and memorable.

Salience determines how easily one’s attention is captured. Harris provides an example of how salience is generated by both schemes and tropes using famous quotes from Shakespeare’s *Romeo and Juliet* (**Juliet is the sun** and **Romeo, Romeo, wherefore art thou, Romeo?**—II.2[201]):

Tropes generate salient expressions because of the way they play on semantic expectations. Schemes generate salient expressions because of the way they play on formal expectations. One does not expect, upon hearing a word like, say, *Romeo*, to hear it again right away. Its linguistic work of referencing a specific individual is already done, so we expect some other words to follow (perhaps, “where are you?”), or maybe silence, but not a repetition. So, the Romeo-trifecta . . . is a scheme (in fact, . . . a couple of schemes) [99].

Rhetorical figures are formed by sets of patterns consisting of linguistic elements delivered to human minds, whether visually or vocally. These patterns thus exhibit neurocognitive affinities, which in turn generate the salience effects. A quick example can be used to demonstrate the salience effect using the set of patterns below. The attention of a reader is likely to be attracted near the two opposite arrows. The arrows resemble the neurocognitive affinities of opposition and balance (which together effect symmetry), therefore making the space more salient than the other shapes. The same salience effect can be generated by rhetorical figures with forms resembling these neurocognitive affinities.



Figure 2.9: A demonstration of saliency. It is more likely for a reader to focus between the two opposite arrows since the arrows resemble the neurocognitive affinities that form an oppositional, balanced, and symmetrical structure. Adapted from Black [22].

As stated by Harris, rhetorical figures create a “figure-and-ground landscape that focalizes some details and put others in relief” [99]. E.g., communicators are attracted by the (sound of the) words or phrases with repeated syllables in rhymes or by the connections established between concepts in different domains when metaphors are used. In other words, rhetorical figures make certain portions of an utterance or passage more salient. As discussed by Black et al. [23], salience effect can be demonstrated through the foreground–background (figure–ground) relation, a part of the Gestalt Psychology.

A figure or foreground refers to the area that stands out, in other words, more salient. A ground or background refers to areas that are more likely to be ignored. This phenomenon can be explained by the CENTER–PERIPHERY or FIGURE–GROUND⁶ image

⁶To avoid confusion with the term “figure” being interpreted as a “rhetorical figure”, this section uses “foreground” and “background” to refer to figure and ground respectively.

schema. Image schema, introduced by George Lakoff [136] and Mark Johnson [116], is a theory in Cognitive Linguistics and philosophy that illustrates mental patterns that are “grounded in and structured by various patterns of our perceptual interactions, bodily actions, and manipulations of objects” [78, 116, 136]. Image schema plays a role in the mapping of perception and cognition (e.g., visual domain to knowledge domain). The idea of the CENTER–PERIPHERY image schema illustrates a mapping from the perceptual domain to the cognitive domain regarding one’s focus. As stated by Johnson, “[s]ince that which perceptually central is most important, then that which is cognitively central is epistemically most important” [117]. Salience is focus, which can be illustrated as the CENTER–PERIPHERY image schema in Figure 2.10. One part, usually the center, stands out compared to the other which fades away in background. Mark Johnson gives a real-world scenario:

This CENTER–PERIPHERY structure of perceptual experience holds for all of our sensory modes, not simply for vision. As my attention is directed to the voice on the telephone, I cease to be aware of the fan humming in the computer on my desk, but I can later shift the center of my attention back to the hum and away from the voice. What is central can become peripheral and what was peripheral can become central [117].

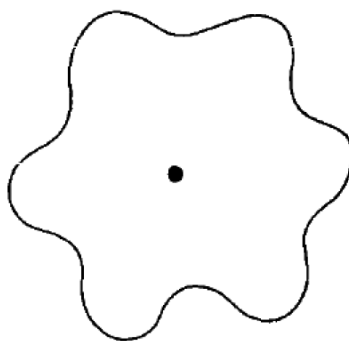


Figure 2.10: The CENTER–PERIPHERY image schema

There can be multiple foregrounds and backgrounds. Elements in an image may both be foreground and background as shown in the famous Rubin’s vase [199] example in Figure 2.11. The image may show two faces facing each other (dark area) or a vase (light area) depending on which area a viewer focuses on. Either the faces or the vase can be seen as foreground at any one time, but never both. There are simultaneously two foregrounds

and two backgrounds. It is very frequent that rhetorical figures work together and multiple figures will resonate to achieve a greater effect of salience in a passage.

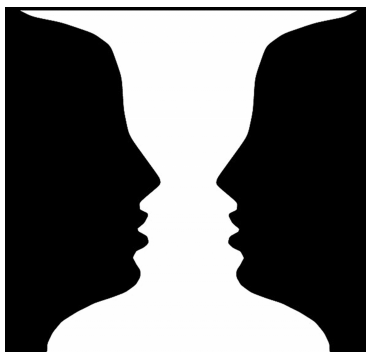


Figure 2.11: Famous Face and Vase drawing, adopted from Black et al. [23] Reproduced from Rubin [199].

As in [Example 2.1.1](#) and [Example 2.1.2](#), the individual rhetorical figures as a combined whole are equally capable of being the foreground. “The importance of this shift between foreground is seen to be the differences between them and their ensuing semantic meanings” [23]. To quote Rubin:

The function of the individual character of the [foreground] shows a close relation to the principle that the difference between two fields is essentially greater when the experienced objects are both [foregrounds] than when they are both [backgrounds]. A field experienced as [foreground] is a richer, more differentiated structure than the same field experienced as [background]. [199, p.227]

Rubin’s analysis identifies not only the importance of seeing the foreground as richer, but also the importance of having multiple rhetorical figures acting together [23].

Neurocognitive affinities are perceptual patterns in the perceptual domain. Salience is an attentional effect in the cognitive domain. Therefore image schemata are suitable illustrations of how neurocognitive affinities generate attentional effects such as salience. Language itself does not generate the salience effect directly, but triggers this mapping between perceptual and theoretical understanding that is already structured in the human mind. Rhetorical figure is the key of natural language to this mapping in the sense that rhetorical figures trigger neurocognitive affinities, which in turn generate attentional effects. The attentional effects generated are different from each individual rhetorical figure since

different neurocognitive affinities are triggered, and the effects become harmonic when multiple figures collocate in the same utterance or passage. I will use another quote from Mark Johnson to conclude the discussion:

We experienced the world meaningfully before we acquired language, both as a species and in our individual growth, so that there is an existential and cognitive continuity between our perceptual and theoretical understanding. Linguistic meaning is thereby prefigured in prelinguistic patterns of significant movement, perceptual interaction, gesture, practices, and communicative interactions [117].

This section walked the path of how rhetorical figures generate a set of attentional effects through the neurocognitive affinities triggered by their forms at a general level. This neurocognitive process is referred as the neurocognitive path of rhetorical figures for the remainder of this thesis and will be discussed in details for figures of perfect lexical repetition in Chapter 3.

2.2 Rhetorical Figure Applications

This section discusses the importance of rhetorical figures in Artificial Intelligence (AI) and Natural Language Processing (NLP) systems, collectively termed as “AI/NLP systems”. Note that although only NLP is mentioned here, rhetorical figures are equally important in Natural Language Understanding (NLU) and Natural Language Generation (NLG). Section 2.2.1 first introduces Computational Rhetoric, a subfield of Computational Linguistics, then discusses the impact of rhetorical figures in various AI/NLP applications. Since rhetorical figures are ubiquitous in natural language, all AI/NLP applications can benefit from embedding knowledge of rhetorical figures, which can be accomplished with the detection and formal representation of rhetorical figures, which are discussed in Section 2.2.2 and Section 2.2.4 respectively. The focus of this research is a specification of the latter.

2.2.1 Rhetorical Figures and AI/NLP

Current AI/NLP systems are focusing on superficial information based on syntactical analysis and semantics. Harris and Di Marco argued that “[t]oo much attention has been placed

on semantics at the expense of rhetoric (including stylistics, pragmatics, and sentiment)” [103]. Rhetoric is the ancient study of style, technique, and effect of persuasion on how knowledge and concepts are communicated through speech or text that focus on attributes of a passage or speech such as style (lexical choice, syntactic structure), purpose (description, persuasion, and instruction), and affect (trust, comprehension, and emotion) [103]. Rhetoric conveys critical information for understanding context and purpose. Thus, it is crucial to be aware of the power of rhetoric in natural language and its importance in an AI system that involves NLP. A possible reason of the negligence of rhetoric in AI/NLP is that some AI/NLP researchers believe that syntax and semantic information are the more fundamental aspects of natural language and should be exploited completely before attempting to analyze the more advanced aspects such as rhetoric [118, 125, 150]. However, as mentioned in previous section, rhetoric is a fundamental aspect of natural language and therefore it is inevitable in any AI/NLP systems. Crosswhite [46, 47] and Fahnestock [67] both recognized the importance of rhetoric in relation with argumentation, a fundamental utilization of natural language. The importance of rhetorical figures for argumentation generally have been discussed by various researchers throughout history [9, 10, 30, 67, 68, 92, 213]. A subfield that focuses on computational approaches of rhetorical argumentation was proposed by Grasso with the name Computational Rhetoric [31, 83, 84, 85, 177]. A main focus in Computational Rhetoric is *stylistic patterning* which focuses on how the “meaning of an utterance is communicated through the relations among its constituents, as well as their relations with contextual and co-textual elements” [103]. Stylistic patterning aims to develop formal computational representations for styles, pragmatics, sentiment and rhetoric that may be applied in an AI/NLP system. The definition of style, as described by Harris and Di Marco, “all the choices a writer [or speaker] makes in his or her words and their arrangement” [119]. With such a formal computational representation, AI/NLP systems able to reason and explain solutions to address concerns of rhetoric such as stylistic flaws and stylistic merits. For example, textual deficiencies detection and repairs, rhetorical strategy recommendation, purposes and sentiment analysis, and document structure can be modified to suit the needs of specific audience and genre [103]. At its core, the formal computational representation of stylistic patterning aims to represent concepts of rhetorical figures.

Although rhetorical figures have been studied for millennia, the establishment of the subfield Computational Rhetoric was fairly recent, both the neurocognitive dimensions and computation methods for rhetorical figures are rarely studied in the field of rhetoric. On the other hand, research on rhetorical figures are also rare in the field of AI/NLP [106] with exceptions on few of the non-scheme figures such as metaphor and sarcasm [99]. Section 2.2.2 summarizes a number of rhetorical figure detection methodologies and tools

that are available to perform detection tasks. However, most of these detection methods and tools have not yet been applied by current AI/NLP systems. Few of even the most ubiquitous rhetorical figures such as plosive have received attention from computer scientists (or even rhetoricians). Rhetorical figures code much valuable information at syntactic, semantic, and pragmatic levels. This information can be incorporated to facilitate a wide range of AI/NLP applications such as argumentation mining [86, 87, 140, 163], sentiment analysis [120, 207], fake news/hate speech detection [36, 141, 167], text summarization [4], text improvement [103], authorship attribution [115, 207], machine translation [43], and translation with focus on maintaining the rhythm of text [134]. The first and most fundamental computational application of rhetorical figure is the automatic detection of rhetorical figures which will be discussed in the following section.

2.2.2 Rhetorical Figure Detection

Harris et al. [103, 106] propose a notation named Waterloo Rhetorical Figure Representation to capture the form of rhetorical figures. For example, the following notation represents the form of antimetabole where $w^x = \text{your country}$, $w^y = \text{you}$ from the famous quote of John F. Kennedy:

Ask not what your country can do for you. Ask what you can do for
your country [124].

$$\dots w^x \dots w^y \dots w^y \dots w^x \dots$$

This notation has been amended and applied in various methods for automatic detection and annotation tools for rhetorical figures. For example, Hromada [112] implemented the Waterloo Rhetorical Figure Representation notation using the Perl-compatible regular expressions. Alliheedi and Di Marco [4] applied the notation to text summarization in a detection method for rhetorical figures that enhanced the performance of MEAD, an extractive multi-document summarizer. Harris et al. then implemented this notation as an XML annotation schema [107].

In 2009, Gawryjolek [77] developed JANTOR (Java ANnotation Tool Of Rhetoric), an automated figure detection and annotation tool that supports manual annotation. The system implements automated figure detection algorithms for figures of repetition such as anadiplosis, antimetabole, epanaphora, polysyndeton, etc., as well as isocolon and oxymoron which are figure of parallelism and a trope, respectively. A large corpus of parsed sentences (the Penn Treebank [149]) was used with a lexicalized Stanford Probabilistic

Context-Free Grammar (PCFG) Parser [126] to tag unknown text and detect rhetorical figures at various positions in syntactic units such as phrases, clauses, and sentences with boundary detection. Syntactic unit boundaries are determined rigorously. A sliding window span on various phrase length (e.g, 2 or 3 sentences) has been used for detection of figures of repetition along with positional information. An extension of the Porter stemming algorithm [190] and WordNet [161] was used for the detection of polyptoton and oxymoron. Experiments were conducted using a number of HTML files with instances of rhetorical figures extracted from various source, including excerpts from political speeches, commercials, the Bible, poetry, prose, lyrics, film dialogues, etc. Gawryjolek reports good precision and recall for the detection of figures of repetition, but only satisfactory results for isocolon and oxymoron.

The detector itself may not be robust by today’s standard. It ignores all punctuation marks, conjunctions, etc. and hard-coded the limit of length of a syntactic unit, although the value can be changed. Also a sliding window cannot account for figures spread in multiple syntactic units. For the detection of oxymoron, it relies on a table of popular oxymorons taken from WordNet. However, the importance of this work goes beyond the detector itself. It is the precedent of many rhetorical figure detection tools which will be introduced in the following paragraphs. It is also an initial effort that demonstrates the role of figure detection in facilitating various AI/NLP applications by applying the detector to annotate rhetorical figures in fourteen American presidents’ inaugural addresses. By identifying rhetorical figures in the president’s inaugural addresses, Gawryjolek observes that the most frequently used figures of speech are epanaphora, isocolon, polyptoton, and polysyndeton. He states that:

This use of [epanaphora] helps create a fluent flow of ideas and, in general, a more cohesive speech . . . the patterns of isocolon establish a good rhythm in the texts and makes them easier to remember . . . Finally, the significant number of polysyndetons is used to stress specific fragments by periodically occurring throughout the text [77].

This effort demonstrated the practical value of rhetorical figure detection and soon inspired other researchers to join the field of rhetorical figures detection. Gawryjolek’s work was later extended by Java [115], who developed *Rhetorica*, an automated figure detection tool intended to facilitate author attribution by combining features extracted from the detected rhetorical figures, e.g., frequency of figures used, with a list of stylometric features in order to analyze author characteristics in a corpus. Both Gawryjolek [77] and Java [115] have made efforts to automatically detect a subset of figures such as polyptoton, parison,

homioptoton, etc., as well as figures of perfect lexical repetitions such as anadiplosis, antimetabole, epanaphora, etc.

Strommer [207] developed a method for author intention evaluation by combining shallow document attributes and rhetorical figure detection. This method focuses on a specific figure, epanaphora, the repetition of words at the beginning of a clause. Strommer’s work takes advantage of the information extracted from shallow attributes, such as gaps, keywords, length of sentences etc. and by detecting certain rhetorical figures, epanaphora in this case, to form a novel metric to evaluate author’s intention in a document. He proposes that “specific rhetorical figures can be tied to particular forms of context, and that it is possible to examine the rhetorical figures of documents to generate enough context information to formulate a classification strategy for document intent” [207]. His work involves an expert annotated corpus used to train a classifier using models such as Decision Tree, SVMs, logistic regression, Bayesian classification, etc. to detect intentionality of the figure epanaphora using refined shallow attributes such as N-gram length, tuple width, gap between repetitions, keywords, punctuation marks, sentence length, etc. An example of unintentional epanaphora is given below using an instance of epanaphora that collocates with antithesis and surmises that antithesis is the primary goal [215].

You can either increase the power, or you can increase the speed.
If you increase the power, then you risk damaging the substrate.
If you increase the speed, then you risk overheating.

Strommer classifies the instance above as an unintended epanaphora since the primary goal is to convey contrast which is the function of antithesis. Antithesis does not require repetition in this case, thus the repetition of epanaphora is simply a by-product, or an augmentation, of the antithesis [207, 215]. Strommer classifies epanaphoras into unintentional and intentional epanaphora from a speaker’s perspective. However, as in the example above, what Strommer thinks as an unintentional epanaphora is actually intended since the repetition in epanaphora supports how the speaker conveys the idea of opposition. Perhaps a more precise term is “intended epanaphora without primary anaphoric goal”. On the other hand, below is an example of an intentional epanaphora with primary anaphoric goal, in which the repetition of **Hurrah** in the beginning of each sentence serves the primary goal of emphasis and adds aesthetic value to the poem [207].

Hurrah for love!
Hurrah for hope!
Hurrah for industry!
Hurrah for bonnie Canada, And her bonnie maple tree!

Document intentionality is an important measurement of authorship attribution which is in turn an important AI/NLP application. Although his work involves only epanaphora, Strommer demonstrated that rhetorical figures in general can provide much useful information that aids the machine learning (ML) classifier implemented to detect intentionality in a document. Other researchers have worked on the classification of rhetorical figures with a ML approach.

Dubremetz and Nivre [58, 59, 60] proposed an approach for automatic detection of the figure chiasmus, which is often a synonym to antimetabole such as Example 2.1.1. The authors argue that “chiasmus should be treated as a graded phenomenon, which leads to the design of an engine that extracts all criss-cross patterns and ranks them on a scale from prototypical chiasmi to less and less likely instances” [58]. The authors propose a ranking system that takes a text file as input and generates candidates for chiasmus with a ranked score by examining features in the text such as stopwords, punctuation, size-related feature, N-gram feature, and lexical clues. Dubremetz and Nivre [60] were able to evaluate a number of instances of rhetorical figures using machine learning classifiers. A limitation for general machine learning approach is the lack of detection tools available therefore no large set of labeled data exist. Their ranking system is based on a measure of prototypicality, i.e., which antimetabole is more “true” than others. Both Harris [95, 107] and Tu [215] argue that many of the high ranking antimetaboles in Dubremetz and Nivre’s ranking system are collocations of antimetabole and multiple other rhetorical figures such as parison and antithesis. For instance, as observed by Tu [215], Dubremetz uses following criteria to give a higher rank to an antimetabole: “perfectly symmetrical switch[ing] of syntactic roles”; “detection of recurrent lexical patterns,” including “the presence of negation underlying a contrast”. The first and third criteria are essentially the definitions of parison and antithesis respectively [215], and the second has a high probability of correlating with mesodiplosis. Antithesis frequently collocates with antimetabole since they have a “natural affinity for one another” [95]. That is, both figures resemble the form that trigger neurocognitive affinities such as opposition and reversal. Harris comments that Dubremetz and Nivre “appear to be unfamiliar with the functions antimetabole serves. But antimetabole is a parade example of form/function correlation. It has a small set of Rhetorical Functions, keyed to the iconicity of its formal structure (which evokes balance and opposition, as well as sequence or priority)” [107].

Dubremetz and Nivre did not consider the form/function correlation and thus the neurocognitive aspects of rhetorical figures are ignored, nor did they consider the multiplicity and collocation of rhetorical figures. Therefore their ranking system cannot explain the reason why one antimetabole is more “true” than another. As early as 2009, Harris and Di Marco [103] envisaged an ontology for rhetorical figures in which the aim is to incorporate

knowledge of rhetorical figures in a machine-readable and inferable computational model. The proposed ontological model later emphasizes representing the neurocognitive aspects of rhetorical figures [106]. It is necessary to distinguish between detection and representation in which this thesis focuses on the latter. It is also necessary to note the advantage an ontological representation can provide when embedded in existing or new rhetorical figure detection tools [103, 106]. Their relationship, metaphorically, resembles the relationship between eyes and brain. An ontological representation of rhetorical figure goes beyond detection, in which it provides the ability to infer about the related knowledge of the figures being detected. On the other hand, an ontological representation is meaningless if an AI/NLP system cannot detect rhetorical figures. Dubremetz and Nivre, as well as all researchers mentioned above, are highly regarded for their great contributions in automatic rhetorical figure detection and annotation. In 2010, O’Reilly and Paurobally [180] made a step towards the ontological representation of rhetorical figures by proposing a figure detection tool that combines figure detection with Web Ontology Language (OWL) [152] ontologies.

The Lassoing Rhetoric (LaRhetO) project of O’Reilly and Paurobally [180] introduced an application that is able to parse a natural language text input with General Architecture for Text Engineering (GATE) [48] and a number of OWL ontologies to produce a knowledge base labeled with linguistic entities including clauses, words, and sentences. This knowledge base was further extended to reference world knowledge from data sources such as DBPedia [13]. The knowledge base was then used to detect a set of rhetorical figures by using Semantic Web Rule Language (SWRL) rules [109]. The authors attempt to capture a wide range of rhetorical figures including both schemes and tropes by assigning a single SWRL rule to each rhetorical figure. The strictness of SWRL rules leads to the omission of instances such as [Example 2.1.2](#), which is an epanaphora with repeated words, i.e., **one**, at the beginning of clauses rather than strictly the first word⁷. The authors modeled classes (concepts) and object properties (relationships) such as `hasFirstWord`, `hasLastWord`, `hasNextWord`, etc. in one ontology, and rhetorical figures such as epanaphora and epiphora in another ontology with SWRL rules [106, 180]. Mitrović et al. report a similar approach in detecting ironies in a Serbian Twitter corpus [163].

Rhetorical figure ontologies are required for advanced automatic figure detection and annotation, processing, understanding and generation, all of which are critical for any AI/NLP tasks. In the next section I will review a number of essential rhetorical figure ontologies, which are the core components envisaged by Harris and Di Marco [106, 103].

⁷Note that the word **one** is at the beginning of the clause, but not the beginning of the sentence.

2.2.3 Ontology and the Semantic Web

Most of today's Web contents are suitable for human consumption rather than machine readable in the sense that machines cannot automatically infer certain results based on the semantics of the content. Web contents could be generated automatically from databases but are usually presented without connections with other data on the web. Current technologies rely heavily on keyword search that lack semantics. Thus there is a need of shift from the *Syntactic Web* to the *Semantic Web*. The Semantic Web movement has been an important activity in today's Web development process. As stated by the W3C, "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries" [128]. The ultimate goal of the Semantic Web is to enhance the web with open, traceable and linked data where the knowledge sources and structures are also shared and connected. It is possible to construct representation of precise definitions using ontologies from various domains as building blocks, thereby reducing the ambiguity of interpretation. The interoperability, understanding, merger and use of data available across the Semantic Web can also be achieved, as well as automated process of the detection of data inconsistency, and the root causes of variations [73, 217].

An ontology is a formal knowledge representation models that enable sharing of reusable and inferable knowledge structures and data. Ontologies represent knowledge in a formal and precise manner. Ontologies also enable sharing of reusable knowledge structures (e.g. classes and properties) and data (e.g., instances). The most cited definition of an ontology is from Gruber: "An ontology is a formal, explicit specification of a shared conceptualization"⁸ [89]. In simple words, an ontology is a set of axioms that define some commonly agreed concepts, i.e., classes and their individuals, and relations among them, i.e., object and datatype properties). In this thesis, as indicated in 1.6, class names are in capitalized Sans serif font, e.g., **Class**, property names are in uncapitalized Sans serif font, e.g., **property**, instance (individual) and example names are in Typewriter font, e.g., **instance1**, when describing components in an ontology. The class definitions of an ontology are formally represented by a set of FOL or Description Logic (DL) axioms. The axioms are specified using XML-based languages such as Resource Description Framework (RDF) and OWL. RDF represents distributed data in triples of the form (subject, predicate, object). For example, (**john**, **name**, "John Smith") is a RDF triple that states the name of the individual **john** is the string "John Smith". RDF Schema (RDFS) adds the ability of defining class and property hierarchies based on RDF. OWL then increases the expressiveness by allowing constraints to be placed on classes and includes most features of RDFS. Thus

⁸Gruber specified the definition with different terminologies in various contexts but is still consistent with this more general version of the definition [144].

most ontologies are currently specified using OWL. Ontologies defined using OWL are easy to implement or integrate in applications. The logic behind OWL is DL which focus on defining classes and properties. A number of DL logic reasoners exist to evaluate the consistency of what is being represented based on the axioms. It is possible to efficiently check if instances satisfy class definitions, if two classes are related and conflict-free, and if a class is subsumed by another. In other words, the reasoners perform instance check, consistency check, and subsumption check. The specification of classes and axioms, and their consistency testing is facilitated using a graphical, interactive editor such as Protégé [174].

Currently, data represented using the Semantic Web format (e.g., RDF(S), OWL) are retrieved by tracing through axioms specified in the ontologies. A SQL-like query language named SPARQL [191] is often used for this purpose. A number of theorem provers or reasoners are available with the ability of automated reasoning that will infer implicit facts buried in the data. In other cases, data and corresponding ontologies are imported and analyzed by applications implemented using logic programming languages such as Prolog [224]. These applications enhance the automated reasoning process beyond the scope of reasoners by adding constraints that are not expressible in DL, and evaluate consistency of data in terms of its context based on imported ontologies [217].

2.2.4 Rhetorical Figure Ontologies

The idea of constructing an ontology for rhetorical figures was delivered more than a decade ago by Harris and Di Marco under a long-term project named *RhetFig* [103, 106, 122], currently re-branded as *Rhetoricon* [105]. The project has inspired a line of research on ontological representations of rhetorical figures [6, 23, 162, 163, 166, 180, 181, 219, 220] including the research presented in this thesis. The ultimate goal of the RhetFig project is to build a neurocognitive ontology for rhetorical figures. The ontology is “neurocognitive” in the sense that it not only captures relations among rhetorical figures, but can also infer the process of how a rhetorical figure generates potential attentional and mnemonic effects, e.g., whether a word or word group is more salient, in order to understand rhetorical strategies embedded in an utterance or a passage [103, 106, 219, 220].

According to Harris et al. [106], the reason to take an ontological approach is due to the cognitive nature of both rhetorical figures and ontologies [106]. Thus a cognitive ontology for rhetorical figures can be applied in any activities that implicates pragmatics or style.

Rhetorical figures are prime candidates for a cognitive ontology. They are both richly, demonstrably cognitive, and richly, demonstrably valuable for NLP tasks

like argument mining. The rhetorical tradition also suggests they hold considerable promise for a range of other automated text processing tasks, such as authorship attribution, genre detection, sentiment analysis, credibility assessment, pathology diagnosis and monitoring, voice interaction systems . . . virtually any activity that implicates pragmatics or style. Ontological representation seemed so obvious to us, so natural, so inevitable [106].

Figure 2.12 shows an overview of a preliminary design of general level concepts of a rhetorical figure ontology, including classification of rhetorical figures and their linguistics properties. It established a foundational framework that provides a guideline for the later ontologies, including the scheme–trope classification, form/function correlation, and the separation of the three domains of rhetorical figure related concepts: the linguistics domain, the rhetorical figure domain, and the neurocognitive domain.

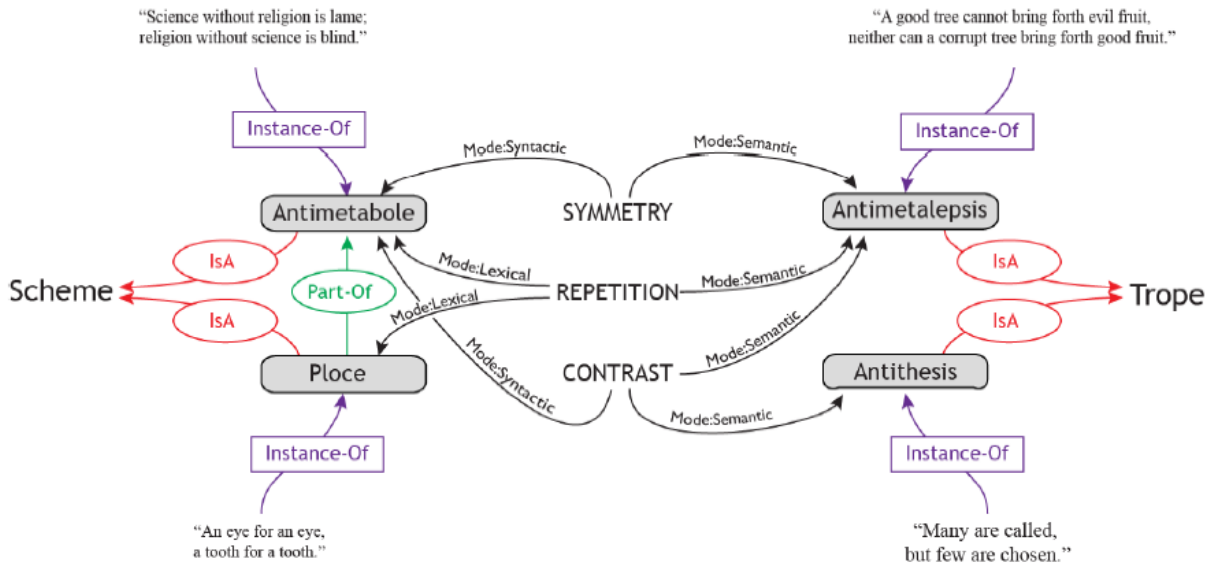


Figure 2.12: Rhetorical Figure ontology, adapted from Harris et al. [106]

Over the decades, efforts have been made using various approaches including the following three general approaches listed by Harris et al. [106]. This research is a middle-out approach in which it focuses a specific subset of rhetorical figures, i.e., figures of perfect lexical repetition.

1. Top-down method, which categorizes types of rhetorical figures in classes and sub-classes,

2. Middle-out method, which identifies specific figures in detail, and
3. Ground-up method, which analyzes each individual instance passage separately

It is a gargantuan task to include all of the patterns identified as rhetorical figures into a single ontology. They are highly disparate, with no reliable or authoritative taxonomy in place, as we have seen. The tradition is also very long, as we have also seen, influenced by multiple disciplines, languages, and scholarly agendas, with a resultingly heterogeneous and inconsistent nomenclature. It is full of synonyms and plesionyms. The Rhetoricon project is developing a refined terminology and rationalized taxonomy, but the task is massive, so its work at this stage is more of a blueprint of its ambitious ultimate goal than an implemented ontology. However, the project has made significant steps towards the goal by developing OWL ontologies for subsets of rhetorical figures such as antimetabole [179], anadiplosis, gradatio, and climax [181] as building blocks. An ontology for the rhetorical figure litotes was modeled by Mitrović et al. [162]. Other researchers have been inspired and adapted this initiative in which rhetorical figure ontologies are being developed for various languages such as Serbian [166] and German [133] under the name *RetFig* (RhetFig without ‘h’) and GRhOOT respectively.

The Serbian RetFig [166] ontology is a formal domain ontology for rhetorical figures in the Serbian language, written in OWL. Figures are classified according to rhetorical and linguistic types and rhetorical operations. More specifically, rhetorical figures are classified based on linguistic domain (e.g., phonological, morphological, and lexical), neurocognitive pattern biases (e.g., repetition, position, and similarity), and traditional categories (e.g., trope and scheme). In the Serbian RetFig ontology [166], the authors reduced the number of linguistic entities to four: **phonological**, **morphological**, **pragmatic**, and **syntactic**, and do not concern themselves with neurocognition or traditional categories. Instead, they modeled rhetorical operations. The overall structure is shown in Figure 2.13. Each figure is assigned a **LinguisticEntity** and a **RhetoricalEntity** class. A **LinguisticEntity** has multiple subclasses such as **LinguisticObject**, **LinguisticScope**, **LinguisticElement**, etc. A rhetorical operation describes how a rhetorical figure is formed, e.g., **addition**, **omission**, **repetition**, **transposition**, **joining**, **separation**, or **symmetry**. For the **RhetoricalEntity**, RetFig differentiates between figures of **pronunciation**, of **meaning tropes**, of **construction**, and of **thoughts**. For each figure, an English name is provided such that a mapping to other linguistic ontologies is possible in the future [220].

A comparison of different ontological modeling of rhetorical concepts developed for argument mining and other applications of computational rhetoric was made in a survey by Mitrović et al. [163], which shows the context between the Rhetorical Structure Theory

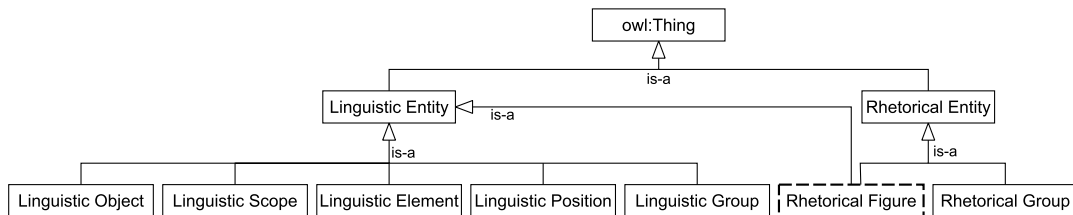


Figure 2.13: Structure of the RetFig ontology, adapted from Mladenović and Mitrović [166].

(RST) [148], the RhetFig proposal, the Serbian RetFig ontology, and the Lassoing Rhetoric project.

GRhOOT, the German RhetOrical OnTology [133], is an adaptation of the Serbian RetFig to the German language. GRhOOT uses the same structure as RetFig (cf. Figure 2.13); however, some figures have been adapted, added, or omitted according to differences in the definitions of figures in the Serbian and the German language. The Serbian RetFig and the German GRhOOT ontologies were merged with the Ploke Ontology [219] proposed in this thesis. The merging of the three ontologies is a demonstration of the modularity and flexibility of rhetorical figure ontologies developed under the framework proposed by Harris and Di Marco [103] and Harris et al. [106]. The merging process is discussed in later chapters.

Since many rhetorical figures are complex figures which are built upon simpler figures, the representation of concepts for rhetorical figures will be more robust as more ontologies for specific rhetorical figures are developed as building blocks for the presumed general rhetorical figure ontology proposed by Harris and Di Marco [103] and Harris et al. [106]. In the previous work of O'Reilly et al. [181] and Black et al. [23], a *Climatic ontology* was developed for the rhetorical figure *climax*, a compound figure of *gradatio* and *incrementum*. A *gradatio* features a sequence of words or phrases repeated at clause boundaries, i.e., a sequence of *anadiploses*. The sequence of repeated words or phrases form an *incrementum* such that there is a semantic increase along the repeated words or phrases [181].

Anadiplosis is the repetition of the last word or word group of one clause and at the beginning of the subsequent clause. Below is an example of anadiplosis with the word **sleet** being repeated in subsequent clause.

Snow turned to sleet, sleet to rain. [54, p.124]

Gradatio is formed by the occurrence of multiple anadiploses in succession. Examples of gradatio are given below:

Out of joy strength came, strength that was fashioned to bear sorrow;
sorrow brought forth joy. [16, p.257–258]

Be secret then, trust not the open air, for air is breath, and breath
blown words raise care. [132, p.372]

Incrementum is a trope of semantic increase. It is often contrasted with another figure, *decrementum*, a figure of semantic decrease. The Climatic ontology combined the figures of incrementum and decrementum into incrementum, as both figures contain a succession of words with scalar, absolute-value increase. The direction of this increase depends on one's point of view and therefore both figures can be viewed as the same figure for the purpose of modeling the Climatic ontology [23, 181]. An example of incrementum is given in Example 2.2.3 with words or phrases **silver**, **gold**, and **precious stones** increasing semantically.

Neither silver, gold, nor precious stones
might be compared to her vertues. [183] (Example 2.2.3)

The compound figure of climax is a gradatio with semantic increase, where the words or phrases repeated in the anadiploses of the gradatio are the same as the words or phrases forming the semantic increase in the incrementum. Again, when gradatio occurs with decrementum, it is often known as *anti-climax*, but for the purposes of the Climatic ontology, both figures are regarded as climax. Examples below are instances of climax where in Example 2.2.4, the repeating elements are **hours**, **days** and **year**; in Example 2.2.5, the repeating elements are **designer** and **person**. These repeating elements form a semantic increase with the final words **age** and **GOD** respectively [23, 181].

Minutes are hours there, and the hours are days,
Each day's a year, and every year an age. [209] (Example 2.2.4)

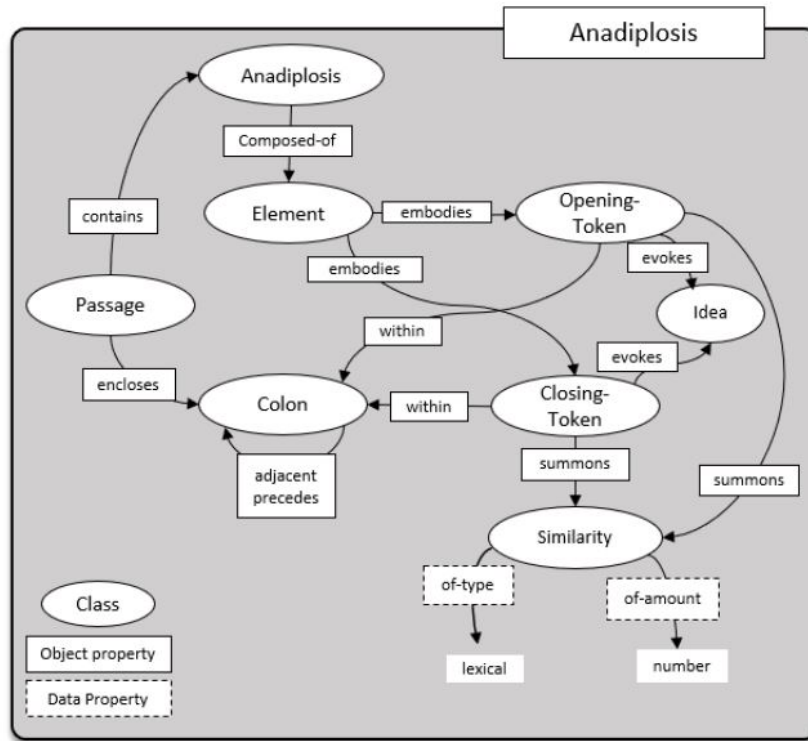


Figure 2.14: Anadiplosis in the Climatic Ontology, adapted from O'Reilly et al. [181]

Design must have had a designer. That designer must have been
a person. That person is GOD. [182] (Example 2.2.5)

The Climatic ontology [181] defined a set of classes and properties that outlined the syntactical structure of the aforementioned figures. As shown in Figure 2.14, a class *Passage* is connected to the class *Figure* via an object property *contains* in which *Anadiplosis*, *Gradatio*, *Incrementum*, and *Climax* are subclasses of *Figure*. The subclasses of *Figure* are connected to a class *Element* which then connected to a class *Token* via an object property *embodies*. The class *Element* represents the abstracted entities that characterizes a rhetorical figure. The *Token* class represents the word or phrase of interests within a passage. For example, each occurrence of the word *designer* and *person* are independent tokens in Example 2.2.3. The tokens of *designer* and *person* are embodied two elements, each corresponds to different instances of anadiplosis. A *Colon* is a clause which is grammatically,

but not logically, complete. Positional and semantic information are represented using only loosely defined class concepts. For example, a class **Series-position** is enumerated to contain three individuals only, i.e., **initial**, **mid**, and **final**. A class **Similarity** is defined to be a class that refers to individuals **lexical** and **semantic** via an object property **of-type** and numerical values via a data-property **of-amount**. OWL ontologies can be used to represent foundational features of rhetorical figures. The Climatic ontology can be enhanced to incorporate more robust representation of basic linguistic units such as word, phrase, clause, etc. with the possible implementation of existing taxonomies such as WordNet [161] and FrameNet [15]. This syntactical information can be used to extract meaningful repetitions from unintentional repetitions such as stuttering. However, even non-meaningful repetitions may reveal information about a speaker, thus a computational representation should be able to recognize such repetitions instead of discarding them [99]. Anadiplosis and gradatio are both rhetorical figures of perfect lexical repetition. The authors define anadiplosis in terms of elements, colons, and tokens. Gradatio is a sequence of anadiploses. This thesis extends these concepts using a more robust and modular ontological representation which expands the coverage to other rhetorical figures of perfect lexical repetition and incorporates notions of neurocognitive affinities such as repetition and position. Due to its limitations, OWL is not able to detect individual equivalence, i.e., repetition, which the property `owl:sameAs` does not capture, positional information, and clause boundaries unless a passage is sufficiently annotated using OWL standards. These are important syntactical characteristics for ploske and other rhetorical figures of perfect lexical repetition. Representation of neurocognitive affinities such as repetition cannot be modeled in OWL with sufficiency. Thus more foundational KR models must be investigated.

2.3 Requirements Elicitation

Requirements engineering in general is an important part of software engineering, since errors could be buried until later stages of development process if requirements are misinterpreted [175]. Boehm’s analysis showed that fixing a requirements error after development costs 100 times more than fixing the same error during the requirements engineering phase of a project [24].

Requirements elicitation is the process of extracting requirements specifications from users or stakeholders. Cheng and Atlee observe that requirements elicitation “comprises activities that enable the understanding of the goals, objectives, and motives for building a proposed software system” [38]. A typical requirements elicitation process consists of interactions between an analyst and a customer during which the customer describes aspects

of the software he/she has in mind. Often a customer will have a high-level idea of what the software should do, but this idea may be vague in the customer’s mind for various reasons, or be difficult to communicate because of such difficulties as the inherent ambiguity of natural language and the use of inconsistent terminologies. The analyst guides the customer with questions that facilitate the generation of precise and detailed requirement specification. Research has been conducted for techniques in the requirements elicitation process including questionnaires and open-ended interviews with the linguistic features analyzed [82]. However, to my and my supervisors’ knowledge of the author, the effects of rhetorical features embedded in utterances that occur during requirements elicitation have not been studied. Rhetorical figures support requirements elicitation because of the clearly demonstrated communicative advantages of using rhetorical figures effectively, and also because they are linguistic devices that have long been associated with creativity, now seen to be a significant aspect of the requirements elicitation process due to the advancement of technology and the recognition of the creative nature of RE process [172].

2.3.1 Interviews in Requirements Elicitation

Techniques in requirements elicitation include introspection and various types of interviews such as questionnaire based interview, open ended interviews, focus groups, and protocol analysis [82]. Interviews are widely used in many circumstances of requirements elicitation, although not all information can be extracted in interviews [81]. However, interviewing is a necessary component of the entire requirements elicitation process. Thus conversation and interaction analyses are heavily involved in requirements elicitation. Goguen and Linde [82] investigated the pros and cons of interview types that are related to requirements elicitation such as questionnaire based interviews and open-ended interviews.

A questionnaire based interview, also known as survey interview, suppresses conversational interactions into a set of instructions with categorized responses from a respondent [208]. Categorized responses are easier for statistical analysis but having the risk of classifying answers that carry unique user information into the category “other” in which user information is lost. As demonstrated by an example in the work of Goguen and Linde, a respondent insists on answering “Christian” when the interviewer posed the question: “do you usually think of yourself as a Republican, Democrat, Independent, or what?”. Goguen and Linde commented: “This mismatch could be the beginning of an interesting exploration of the respondent’s religious and political categories . . . because this is forbidden for survey interviewers, this fascinating informant probably ends up as a bleached ‘Don’t Know’ or ‘Other’” [82].

Open-ended interviews are less restrictive where the respondent is able to answer a question posed by the interviewer freely. The interviewer is able to guide and steer the direction of the conversation. Goguen and Linde argued that open-ended interviews suffer from *linguistic incompetence*. When asked to describe an activity, the respondent may not be able to describe the tacit knowledge involved even if he/she is familiar with the activity, e.g., describing how to tie shoelace [82]. One technique suggested is to compare elicited discourse with non-elicited speech that is spontaneously produced by respondent. Wolfson showed that elicited narratives are different on fine level of detail when compared to spontaneously produced narratives since the latter may include negotiations between the speaker and other interlocutors [225]. Goguen and Linde also suggested that the comparison should be done after the “analysis of elicited data has suggested some structures of interest, because memory for linguistic structure in natural settings is generally not sufficiently reliable” [82]. It is to the interest of this research to discover whether more information and tacit knowledge can be extracted by analyzing rhetorical figures, along with domain knowledge incorporated, in both elicited and non-elicited discourse.

The importance of interviews in the settings for requirements elicitation was further emphasized in the work of Donati et al. [57]. The success of an interview can be influenced by factors such as domain knowledge, cognitive strategies, and the communication between customer and analyst. The communication skills of an analyst is considered to be an important factor during a requirements elicitation interview [57]. A specific type of interview is a role-playing interview in which a respondent and an interviewer play roles such as a customer and an analyst in the setting of requirements elicitation. In the work by Donati et al., role-playing interviews were conducted among university students in order to train the students with appropriate skills to perform effective requirements elicitation interviews. Donati et al. stated that “existing research in the field of Requirements Engineering Education (REE) have shown that role playing is an effective pedagogical approach to enable students to learn from experience.” [57]. The goal was to identify common student mistakes during the role-playing interviews in order to lay foundation for future research in the area of REE. Thirty-eight undergraduate students were recruited as part of the curriculum of a course. The students were divided into two groups, namely customer and analyst. The task of each customer was to imagine a novel computer intensive system that they wish to be developed, while the analysts were given a 2 hours lecture on techniques of requirements elicitation interviews in which they received general guidelines on how to conduct different types of interviews. There were 19 interviews conducted simultaneously between a customer and an analyst.

Donati et al. [57] listed a number of mistakes extracted from the role-playing interviews performed by the students. Typical mistakes include: wrong opening and closing,

unleveraged ambiguity, implicit goals and stakeholders that were not clearly identified during the interview, ignored non-functional requirements, etc. Many of the mistakes would be avoided by professional analysts. But it is also worth to realize that some of the mistakes may occur even in professional settings, especially with novice analysts and customers without knowledge of requirements engineering. Additional communications are needed in order to clarify noticed mistakes, but some may still be unnoticed. Being able to analyze the linguistic features during a conversation would be useful in reducing or even eliminating these errors potentially, thus increasing the efficiency of a requirements elicitation interview. For example, Donati et al. [57] gave an example for unleveraged ambiguity as illustrated below where “A” and “C” are analyst and customer respectively:

...the customer wants to create a social network dedicated to those travelers interested in nature and wilderness, and, among other features, he requires users to register to his platform. The analyst is not convinced of the necessity of a login mechanism. The fact that the analyst is reluctant to accept this feature is probably a sign of some sort of misunderstanding. The analyst asks: (A) You want to make it exclusive, only to users who login. Can you explain more about the reasons why people need to login? (C) Look, I’m a traveller, a tourist or a naturalistic enthusiast who want to see animals in the wild. [...] If I want to see a polar bear I have to know that polar bears are not something that you can find everywhere in the wor[l]d, you can find it only in the southern part of the globe [...] and it is the kind of information you find in the system. The customer clearly misunderstood the question. Instead of solving the misunderstanding, the analyst decides to let the customer talk.

Another example was given by Donati et al. [57] to demonstrate the mistake of implicit goal, which is a goal that was never stated or explained explicitly. In the following example, the analyst tried to understand the implicit goal by posing a follow-up question to the customer. However, the question was not able to elicit the implicit goal from the customer. In other cases, the analyst may be more passive in which he/she does not initiate a question that attempts to explore the implicit goal from the customer.

The customer starts as follows: (C) The name of the app is gonna be Text Later, and basically what it’s gonna do is, I’m gonna put a text into a field, I’m gonna set a time, I’m gonna set the recipient, and it’s gonna text that person at that time (A) That’s interesting, do you have a particular user group in mind? (C) Anyone who wants to ... basically the problem happens when you want to

text someone at a certain time, but then you do not remember to text them at that time, so basically it's just a timer that goes on, and the text automatically goes from my phone (A) Can you think of a particular use case for this? (C) Ok, I sleep late at night at 1 a.m., but I want to text someone at 6 a.m., I will not wake up at 6, I just put that text in, set a timer, and it's good to go (A) Ok. The analyst appears to ask for a particular use case, since the application does not seem to have a reasonable goal. The use case does not sound realistic: why should one need to text someone at a specific time? In this example, we do not know whether the analyst has actually understood the goal, or if he said Ok just to close this argument and start discussing other aspects.

To summarize the investigations described above, interview methods can fail when an interviewer and a interviewee:

1. do not share a common vocabulary or belief,
2. do not know how to describe a certain aspect to each other, or
3. do not want to discuss a certain topic.

Cases 1 and 2 are communication pitfalls in which rhetorical figures are able to help naturally, while Case 3 may become more obvious when rhetorical figures are analyzed during a conversation. A hypothesis is that it is possible to extract information and clues when rhetorical figures can be recognized in conversations. From the other direction, users can respond with more details and precision when an interviewer asks the same question in a different form by embedding certain rhetorical figures in the question. It is still unknown whether certain rhetorical figures may affect the resulting software requirements specification. Human analysts may need to undergo training to become familiar with the use of rhetorical figures.

2.3.2 Conversation Analysis and Discourse Unit

As stated by Goguen and Linde, conversation analysis “attempts to describe the underlying social organisation that makes conversation orderly and intelligible. Conversation is one of the most prevalent yet invisible forms of social interaction, and may be considered typical of how people construct their world in an orderly way” [82]. Systematic features involved in conversation analysis are turn-taking and adjacency pairs. A conversation is defined

technically as an “interactional system in which turns are not preallocated, i.e., in which the order of interaction is negotiated in real time, as the conversation proceeds” [82]. Turn taking analysis focuses on the gap or volume change between the speakers who take turns at a turn transition point during a conversation. A turn transition point is a syntactical and semantic end of an utterance. An adjacency pair is a pair of action and reaction such that the action produces the reaction. For example, “sequences like question–answer and greeting–greeting, where one speaker’s production of a question or greeting projects another speaker’s production of an answer or second greeting” [82]. Both turn taking and adjacency pairs are important components of conversation organization that contribute toward the creation of social order in the process of requirements elicitation. A social order characterizes the orderly nature of social interaction and it is produced by the participants during interactions. The social order created in a conversation is “the normative form of conversation: there should be one speaker at a time, with no gaps or overlaps” [82].

A discourse unit is a bounded linguistic unit that groups a set of sentences together, e.g. a joke, an explanation, plan, spatial description, or an oral narrative of personal experience. A discourse unit has defined boundaries and a precise internal structure. In most cases, the listeners are able to identify the defined boundaries of a discourse unit, e.g., the end of a narrative. Turn-taking plays an important role of establishing such boundaries, while “other things being equal, the sentence is the potential unit of turn exchange; i.e., a second speaker may begin to speak when the first speaker has reached a permissible end for his sentence. However, if the first speaker has negotiated permission to produce a recognized discourse unit, such as a joke or a story, then that speaker has the floor until the unit is completed. A second speaker may contribute questions, appreciations, side sequences, etc., but the discourse unit and topic in progress will not be changed until the unit is recognised as completed” [82]. However, Goguen and Linde did not mention how the defined boundaries of a discourse unit can be affected when interruptions occur. A precise internal structure is a property of the discourse unit that is “just as describable as the sentential syntax” [82]. This internal structure is embedded in the interactional process of discourse construction. It enables better understanding of sections of a narrative and the tasks of listeners and interlocutors at these sections. The understanding of a discourse is particularly important in requirements elicitation since “much of what is communicated between the parties will be framed as stories, e.g., about what our group does, what we hope to accomplish with the new system, what our problems are, etc.” [82]. Goguen and Linde used an example of how repairing personnel of photocopy machines use stories and narratives outside of formal training sessions to give valuable advices for novice technicians. Other case studies indicate that evaluations of narratives and stories could be used to “reconstruct a value system for an organisation, and where task-oriented discourse was

used to determine work structure” [82].

Conversation analysis and discourse unit are linguistic approaches that have been widely used to study aspects of verbal data in requirements elicitation. It is worth reviewing the opinions about linguistic features and techniques that will benefit requirements elicitation although rhetorical figures were not mentioned explicitly, to the knowledge of the author, in previous work. This research attempts to highlight the importance of rhetorical figures during requirements elicitation interviews since the information carried by the figures is significant. The attentional effect of implementing rhetorical figures in conversations in requirements elicitation interviews are being investigated in a pilot-study introduced in later chapter.

Chapter 3

The Concept of Ploke: Rhetorical Figure of Perfect Lexical Repetition

3.1 The Neurocognitive Path of Rhetorical Figure

Chapter 2 described the neurocognitive dimensions of how a rhetorical figure generates attentional effects through the neurocognitive affinities triggered by its form. This process is summarized as the neurocognitive path of rhetorical figure. It simply states that:

A rhetorical figure is a form/function pairing. The amalgamation of form and function triggers a set of neurocognitive affinities. The neurocognitive affinities generate attentional effects.

The neurocognitive path is an outline that draws the map from semiotics to linguistics, then to neurocognition as described in Chapter 2. Specifically, an utterance or a passage is transferred between a speaker and a receiver during communication. The utterance or passage contains rhetorical figures. A rhetorical figure has a form and a function. The amalgamation of its form and function triggers a set of neurocognitive affinities, which are patterns that our minds tend to capture. E.g., a repetitive, contrastive, symmetrical or balanced structure is more likely to capture a reader's attention as demonstrated with the opposite arrows in Figure 2.9 in Chapter 2. A neurocognitive affinity in turn generates attentional effects such as salience, aesthetic pleasure, and increase in memorability. E.g., the opposite arrows are more salient than the other shapes in the same image. A graphical view of the neurocognitive path of a rhetorical figure is shown in Figure 3.1.

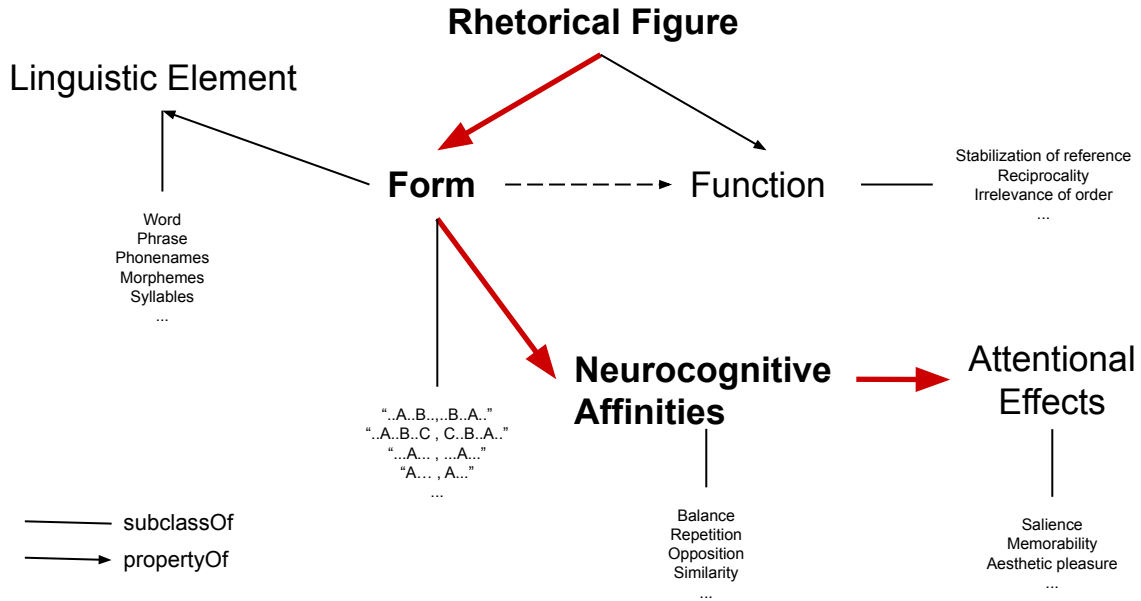


Figure 3.1: The neurocognitive path of rhetorical figure. The Form branch is highlighted in red. The dashed line between Form and Function indicates that there is a correlation between them. How are they related and details of the Function branch are yet to be discovered.

There are two branches splitting from the Rhetorical Figure node on the neurocognitive path, the Form branch and the Function branch. This thesis focuses on the Form branch of the path, as indicated by the red arrows in Figure 3.1. As previously mentioned, the form of a rhetorical figure, especially a scheme, is the computationally tractable portion of that figure. Many rhetorical figure detectors are able to detect and annotate a subset of scheme figures along with a small number of tropes. Since the goal of this research is to construct a formal computational model, it is more suitable to exploit the Form branch rather than exploring the relatively abstract Function branch at the moment. Function is inevitably another essential component on the neurocognitive path. However, its connection with neurocognitive affinities and in turn the attentional effects is outside the scope of this thesis. There is certainly a correlation between form and function of a rhetorical figure [67, 103]. Harris [100] discusses this correlation by illustrating how the form of a scheme enacts its meaning with principles of iconicity. His discussion focuses on *chiasmus* which is a pattern formed by reversed repetitions (e.g., *ABBA*). It resembles the form of scheme figures such

as antimetabole. However, it is still relatively unclear how this correlation works exactly, hence the dashed line in Figure 3.1. Harris recently argues that the rhetorical functions are conveyed not only by the figures themselves, but the combination of rhetorical figures, the collocation of schemes such as antimetabole, mesodiplosis, and parison, along with grammatical features [101, 102]. The Function branch needs to be researched more deeply in terms of rhetorical studies before a computational model can be constructed. It is, however, the next important step to take in order to complete the neurocognitive path. Recall that the ultimate goal of Rhetoricon is to develop cognitive ontologies for rhetorical figures. To realize this goal, a cognitive ontology aims to represent the concepts related to a rhetorical figure as detailed as possible along the neurocognitive path.

The neurocognitive path can now be rephrased to describe the Form branch specifically:

A rhetorical figure is a form/function pairing. The form triggers a set of neurocognitive affinities. The neurocognitive affinities generate attentional effects

The components of the Form branch of the neurocognitive path are the following concepts which are already discussed:

1. Rhetorical Figure
2. Form of a Rhetorical Figure
3. Neurocognitive Affinities
4. Attentional Effects

This research focuses on a subclass of scheme called plope, rhetorical figures of perfect lexical repetitions. The form of plope is simply lexical repetitions, which are easily tractable computationally and ubiquitous in natural language. The form of plope is also independent of language. As I will demonstrate in later section, one can still interpret information carried by plokess in a passage even without any semantic knowledge. When a receiver possesses the knowledge of plope, the receiver is able to extract information from the lexical repetitions of a passage written in an unknown language. Plope is not merely repetitions. It consists many variations that serve attentional, aesthetic, and mnemonic purposes (as well as different communicative functions) as discussed in later sections. Lexical repetitions can be unintentional but are meaningful [99]. Plope is therefore a computationally tractable, fundamental, and fruitful rhetorical figure to be investigated to facilitate AI/NLP systems.

This thesis follows the definition of Harris [99] which defines plope as a family of figures. Plope includes a set of rhetorical figures of perfect lexical repetition that may have positional constraints. Thus, detecting lexical repetitions is trivial, but detecting plokcs is not. Most detection tools discussed in Chapter 2 are able to detect figures in the plope family with fair results. The next step is to move forward from detection to representation as mentioned in Chapter 2. An ontology for plope fulfills the representation side of the spectrum thus an AI/NLP system is able to infer about knowledge related to plope figures.

The neurocognitive path of Plope is a specialization of the neurocognitive path of a rhetorical figure. Therefore an ontological model of plope looks to represent the concepts along the neurocognitive path but tailored specifically to plokcs. Each of the following concepts is a subconcept of the concepts mentioned above.

1. Plope
2. Form of a Plope
3. Neurocognitive affinities triggered by the Form of a Plope, i.e., repetition and position
4. Attentional Effects generated by repetition and position

Each concept is summarized as follows:

Plope: A plope is a subconcept of a rhetorical figure. For example, given a passage ...*abcda*... in which ‘a’, ‘b’, etc. are linguistic elements, we say the passage contains an instance of plope since there is a repetition of ‘a’. A linguistic element is a basic linguistic unit such as a word, syllable, phrase, clause, phoneme, lexeme, morpheme, sememe, etc. It can be simplified to a word, a word group, or a phrase in the case of plope since plope deals with only lexical repetitions.

Form: The form of a rhetorical figure consists of linguistic elements. The form of a plope, given the same passage ...*abcda*..., is the tractable portion ...*a...a...* which consists of the linguistic elements being repeated. In this case, it is the linguistic element ‘a’. Note that ...*a...a...* should be distinguished from the concept of the form of a plope. One can view the form of a plope (together with the concept plope) as a filter or a set of arbitrary sequential procedures that transforms the passage ...*abcda*... into ...*a...a...*. Note that the form of a plope relates to linguistic elements in the filtered passage but the form itself is not a passage (nor strings). In other words, the passage ...*a...a...* is a visualization of the form of plope, but not the form itself.

Neurocognitive affinities: The form of plope triggers a set of neurocognitive affinities, which are patterns that are easily recognized by human minds. It may be relatively difficult to distinguish the difference between repetition as the form of a plope and repetition as a neurocognitive affinity. The form of a plope (or of a rhetorical figure) is the tractable object that is part of the plope, which is in the perceptual domain. On the other hand, a neurocognitive affinity is a concept in human mind that is not easily tractable, which is in the neurocognitive domain. One the subgoals of this thesis is to construct a conceptual model to capture neurocognitive affinities triggered by forms of plope figures, i.e., repetition and positions. In this thesis, I keep the term “repetition” to refer to the neurocognitive affinity and “form” to refer to the form of a rhetorical figure unless otherwise stated. It is also important to distinguish the concept of form and neurocognitive affinities as it leaves the potential to connect with future rhetorical figure ontologies.

Attentional effects: Attentional effects are generated by the neurocognitive affinities triggered by the form of plokess on a receiver. A receiver may perceive a part of or the entire passage as more salient, aesthetically pleasing, or more memorable, etc. when a plope (and rhetorical figures in general) is present, as in [Example 2.1.1](#). Formally representing the attentional effects is beyond the scope of this thesis since the domain still requires extensive research from researchers in rhetoric, cognitive science, psychology, etc., and is, in any case, infinitely variable (even if variable within specific parameters), as a function of individual psychology (fatigue, mental or pharmaceutical factors, and so on) and environmental contexts (physical noise, discursive priming, and so on). It is important to note that attentional effect, along with function, are both important aspects of a rhetorical figure that should be carefully looked into, whether using a knowledge representation approach, a machine learning approach, or a combination of both. It is our ultimate goal to formally represent these aspects as part of the rhetorical figure ontology in future when more theories from the study of rhetorical figures become available, which completes the neurocognitive path.

In the following sections we use the terms “form”, “neurocognitive affinities” and “attentional effects” to refer to the subconcepts related to plope as described above. The following sections discuss the definitions of plope, its form–function correlation, the neurocognitive affinities triggered by forms of plope: repetition and position, and the attentional effects generated.

3.2 Ploke Overview

The terminological and conceptual history of rhetorical figures is uneven at best, and plope is a case in point. It is traditionally defined as “the intermittent or unpatterned reappearance of a word” [71], distinguished from figures like antimetabole or anadiplosis, in which words do exhibit patterns in their occurrences.

Originally, plope was used as the term of a single rhetorical figure of perfect lexical repetition only [67]. A perfect lexical repetition is when both the form (signans) and the meaning (signatum) of a word or phrase are repeated [67]. That is, “the repetition of a word or word group with no variation of signans or signatum” [99]. Polyptoton is a figure with a repetition of a word with different morphology. Thus, it is a figure of lexical repetition with varied signantia that brings along its “evocation of the signatum” [99]. For example, the quote *Power tends to corrupt, and absolute power corrupts absolutely* involves words *absolute* and *absolutely* [1] which have different forms but are derived from the same root word. Antanaclasis is a figure in which a term is repeated but with different meanings. Thus, it is a figure of lexical repetition with the same signans but varied signata. Note that an antanaclasis is not considered as a plope because of the conceptual difference. It is considered as a trope. For example, the phrase *If you don’t get it, you don’t get it* involves two different tokens since the semantic meanings are different, although both have the same form of *get it*¹.

But as Harris [99] argues, plope is better viewed as a class of perfect lexical repetition figures (otherwise unconnected in the classical tradition) rather than a single figure. Other figures of perfect lexical repetition such as anadiplosis, antimetabole, epanaphora, mesodiplosis, etc. are all specified versions of plope with positional constraints. Harris et al. [106] makes the distinction between Simple Plope and Complex Plope. Simple Plope is the unpatterned default repetition of words or phrases and Complex Plope is the class of figures, like antimetabole and anadiplosis, in which multiple occurrences of words are positionally patterned, either with respect to each other (e.g., antimetabole) or to larger units of discourse (e.g., anadiplosis). Simple Plope has only one member called *conduplicatio*, one of the many synonyms used to designate unpatterned lexical repetition. Complex Plope has many members as shown in Figure 3.2. Definitions and examples of subtypes of simple and complex plope are shown in the next section, with the repeated words or phrases underlined.

¹This is a marketing quote from the *Washington Post*. The first *get it* refers to getting the object, in this case the newspaper. The second *get it* refers to obtaining the knowledge (from the news).

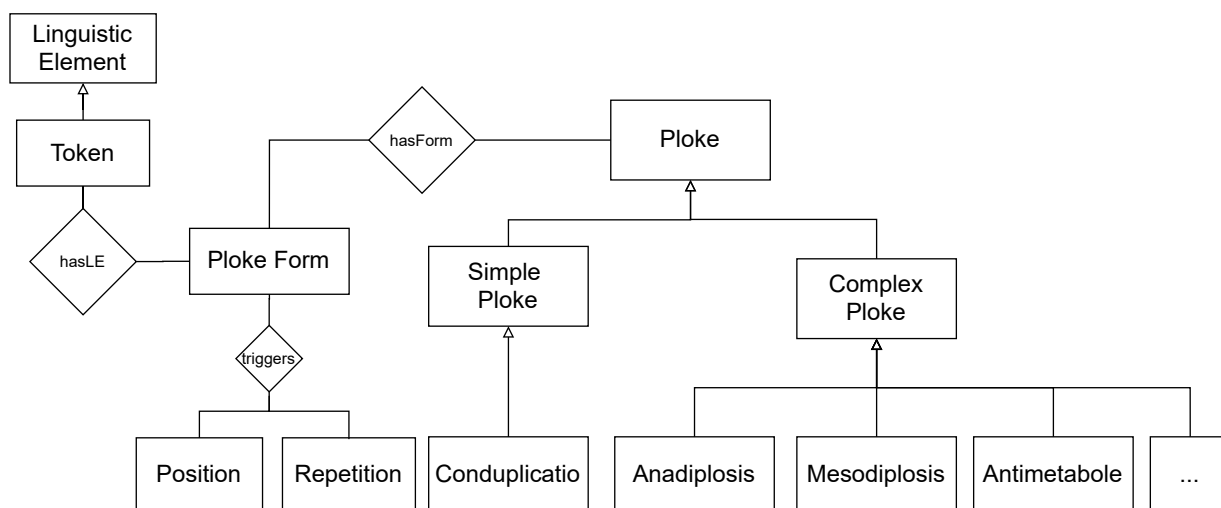


Figure 3.2: Ontological view of plope, proposed by Harris [99] and Wang et al. [219]

3.3 Definition and Examples

Definitions and examples of subtypes of plope are shown below, with the repeated words or phrases underlined. The definitions and examples are adapted from Harris and Di Marco [104]. Some are copied from Chapter 2 for reader's convenience.

Anadiplosis: the repetition of a lexeme or lexical group on either side of a clause or phrase boundary.

... you won't prevent poverty. Poverty being more than income ... [140]

Antimetabole: the proximal occurrence of the same two lexemes or lexical groups in reverse orders.

Ask not what your country can do for you. Ask what you can do for your country. [124]
(Example 3.4.5)

Conduplicatio: unpatterned lexical repetition.

Epanalepsis: lexical repetition at the beginning and ending of a phrase or clause.

Boys will be boys.

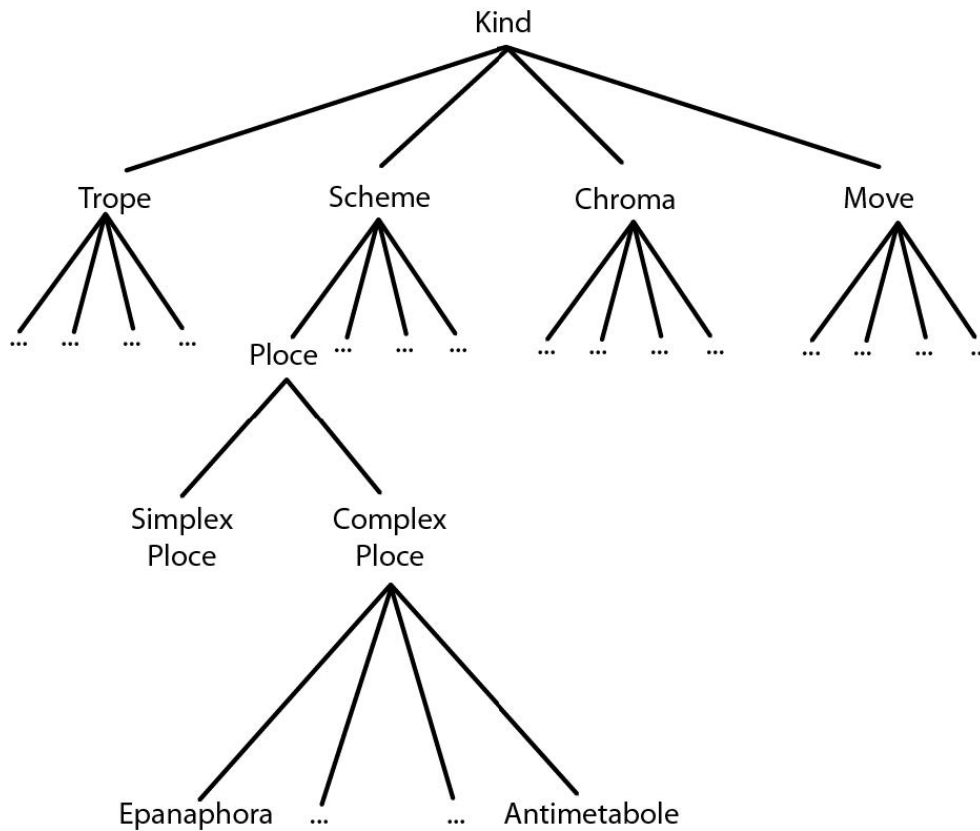


Figure 3.3: Taxonomy of Ploke, adapted from Harris et al. [106]. Note “Ploce” is an alias of Ploke.

Epanaphora: the occurrence of the same lexeme or lexical group at the beginning of proximal clauses or phrases. A synonym to anaphora.

That’s one small step for man, one giant leap for mankind. [12]

Epistrophe: the occurrence of the same lexeme or lexical group at the end of proximal clauses or phrases, a synonym to epiphora.

If I lend you money, I’m taking a risk. And I should carry that risk. [140]

Epizeuxis: perfect lexical repetition when a lexeme or lexical group recurs immediately.

Long, long ago.

Gradatio: A sequence of anadiploses.

Man behaving strangely is confronted by police. Police shoot man.
Man dies.

Mesodiplosis: the occurrence of the same lexeme or lexical group in the middle of proximal clauses or phrases.

We were elected to change Washington, and we let Washington change us. [139]

3.4 Form/Function Correlation of Plokes

A rhetorical figure is a pairing of form and function. As a rhetorical figure, plope inherits this property. The form of a plope consists of repeated words or phrases and triggers a set of neurocognitive affinities such as repetition, balance, opposition, position, etc. Recall that the form of an antimetabole such as [Example 2.1.1](#) is:

$$\dots A \dots B \dots B \dots A \dots$$

where A and B are the words or word groups being repeated ($A = \text{all}$ and $B = \text{one}$), and “...” represents other linguistic elements that are ignored. Using the same notation (a simplified notation of Waterloo Rhetorical Figure Representation) with ‘,’ to represent clausal boundaries, the forms of plope figures are listed below:

Anadiplosis:

$$\dots A, A \dots$$

Epanalepsis:

$$A \dots A$$

Epanaphora:

$A \dots, A \dots$

Epistrophe:

$\dots A, \dots A$

Epizeuxis:

$\dots AA \dots$

Gradatio:

$\dots A, A \dots B, B \dots$

Mesodiplosis

$\dots A \dots, \dots A \dots$

The most important functions of plope are to *stabilize reference* and *emphasize* the concept conveyed by the repetition. Repetition of a word or phrase in a passage or speech stabilizes the reference to increase its clarity in context. A perfect lexical repetition suggests that it is indeed the same concept that is being conveyed. The best way to ensure precision of reference is exact, or ‘perfect’ repetition, which is seen most clearly with the use of variables in mathematics and symbolic logic. Fahnestock’s analysis suggests that repetitions are crucial in scientific writing where it is important to reduce or eliminate ambiguity [67], thus, plope could be the “ultimate procedure directed by scientific language against ambiguity” [198]. As the example demonstrated by Aitchison [2] and cited by Harris [99] as shown below:

Peter bathed the dog on Tuesday and Mary bathed the dog on Wednesday.

in which a simple omission of the repeated phrase yields an ambiguous sentence:

Peter bathed the dog on Tuesday and Mary on Wednesday.

One can also replace the second **bathed the dog** with non-repetitive phrases such as **did the same** or **did it**. While readers may still be able to interpret the concept being conveyed by the sentence, all of which will require some additional context of the sentence.

Another function of plope is to emphasize the concept conveyed by the repeated word. The more a word, phrase or clause is repeated, the more it stands out from a sentence or a passage. Both stabilizing reference and emphasizing concept conveyed are functions related to plope. In addition, subtypes of plope have specific functions such as to increase the significance of quantity, reciprocity, and irrelevance of order, etc. which will be discussed in the following paragraphs.

In some cases, repetition also increases the degree of measurement of quantifiable concept conveyed by the repeated word. For example, in sentences that contain epizeuxis, a subtype of plope, such as **long long ago** and **far far away**, in which the concepts conveyed by **long** and **far**, i.e., the measure of temporal duration and distance, are elongated by the number of repetitions appeared [99].

An antimetabole has several functions, depending on its interaction with other figures and with grammatical elements. A function of antimetabole is to convey the idea of *irrelevance of order or rank*, that is, the order or rank of A and B does not matter. For example, **Ladies and gentlemen, gentlemen and ladies**. Another function of an antimetabole is to generate a focus on reciprocal relationship [67] in addition to the functions of plope. The reversed repetition often suggests a *reciprocal relation* between the repeated words A and B . For example, in propositional logic, the equivalence relation $A \leftrightarrow B$ can be expressed as: $A \rightarrow B \wedge B \rightarrow A$. Recall Peirce's treatment of algebra as diagrams in Chapter 2 and this formula has the same form as Example 2.1.1, which includes an antimetabole, i.e., it has the form of $\dots A \dots B \dots B \dots A \dots$. More generally, let R_1 and R_2 be binary relations, A and B be atomic concepts, then a reciprocal relation between A and B can be represented as

$$R_1(A, B) * R_2(B, A) \quad (\text{Formula 3.4.1})$$

where the $*$ can be any connective symbol, e.g., $\wedge$, $\vee$, $\rightarrow$, or $\leftrightarrow$, which does not affect the antimetabole. This is represented graphically in Figure 3.4.

In Example 2.1.1, the reversed repetition suggests an equivalent reciprocal obligation between **all** and **one**, i.e., an entity of group, organization, or community supports an individual while an individual contributes to that entity. Thus, let **for** be a binary relation, we have

$$\text{for}(\text{all}, \text{one}) \rightarrow \text{for}(\text{one}, \text{all})$$

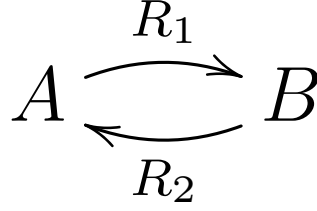


Figure 3.4: Reciprocal relation between A and B

Note that the symmetrical case in which $R_1 = R_2$ is achieved in combination with mesodiplosis, i.e., the medial repetition of the word **for**.

The function of irrelevance of order or rank also applies in [Example 2.1.1](#), thus the rank of **one** and **all** does not matter. Therefore [Example 2.1.1](#) may also be expressed as:

One for all, all for one

which can be expressed as:

$\text{for}(\text{one}, \text{all}) \rightarrow \text{for}(\text{all}, \text{one})$

The conjunction of the expressions above results in an equivalence relation:

$\text{for}(\text{all}, \text{one}) \leftrightarrow \text{for}(\text{one}, \text{all})$

Another example of equivalent reciprocal relation is Newton's Third Law of Motion, in which the reciprocal relation is the reciprocal force between two entities.

If you press a stone with your finger,
the finger is also pressed by the stone [171]. (Example [3.4.6](#))

In this case $A = \text{stone}$ and $B = \text{finger}$ and $R = \text{press}$,

$\text{press}(\text{finger}, \text{stone}) \rightarrow \text{press}(\text{stone}, \text{finger})$ (Formula [3.4.2](#))

The reciprocal force relation exerted by **press** acts on both directions between **finger** and **stone**. However, one may argue that this is not an equivalence relation. That is, if somehow your finger is pressed by a stone, will your finger press the stone back? This is true according to Newton’s Third Law of Motion in which the finger also exerts a reaction force on the stone pressing it. Therefore, the following is also true:

$$\text{press}(\text{stone}, \text{finger}) \rightarrow \text{press}(\text{finger}, \text{stone})$$

Thus the equivalence holds,

$$\text{press}(\text{finger}, \text{stone}) \leftrightarrow \text{press}(\text{stone}, \text{finger})$$

The antimetabole in Newton’s text conveys the function of reciprocal force between the two entities finger and stone. The presence of antimetabole supports Newton’s statement of the Third Law of Motion [67], i.e., all forces come in pairs with equal magnitude and opposite directions. This becomes more obvious if we change the relation $\text{press}(A, B)$ to $\text{force}(A, B)$ which indicates the force exerted by A on B . The following equivalence still holds for entities **finger** and **stone**.

$$\text{force}(\text{finger}, \text{stone}) \leftrightarrow \text{force}(\text{stone}, \text{finger})$$

Generalizing to all entities yields the following equivalence which is a representation for Newton’s Third Law of Motion in First-Order Logic.

$$\forall x, y \text{ force}(x, y) \leftrightarrow \text{force}(y, x) \quad (\text{Formula 3.4.3})$$

The goal of [Example 3.4.6](#) is to articulate the idea represented by [Formula 3.4.3](#). A receiver interprets [Example 3.4.6](#) by going from [Formula 3.4.2](#) to [Formula 3.4.3](#) as demonstrated above. You may notice that antimetaboles exist in all notations despite whether it’s in natural language or logical formulas. This is because “inverse repetition is the most natural, lucid, and mnemonic way to express reciprocity” [100]. What Harris [100] calls a chiasmic structure or inverse repetition resemble the form of an antimetabole. In general, antimetabole conveys the function reciprocity thus its presence supports the conveyance of ideas involving reciprocity. In this case, antimetabole conveys the function of reciprocal force, which unifies with the idea that [Example 3.4.6](#) tries to convey. This becomes less obvious the antimetabole was formed by reversed repetition of less meaningful words such as stop words. It is possible to outline a model that illustrates the relationships between

the functions of antimetabole or rhetorical figures in general. For example, both irrelevance of order and reciprocal force can be specifications of reciprocity. However, such a model is outside the scope of this thesis and a potential direction to explore in the future.

Consider the following example in which R exists between A and B but not equivalent.

Anyone who thinks he has a solution does not comprehend the problem
and anyone who comprehends the problem does not have a solution. [138]
(Example 3.4.7)

where $A = \text{has a solution}$ and $B = \text{comprehends the problem}$. Converting it to propositional logic we have,

$$(A \rightarrow \neg B) \wedge (B \rightarrow \neg A)$$

Note that this is not strictly an antimetabole with the added negation on A and B . It is not an antithesis, which sometimes combines with antimetabole as in Example 3.4.5, which requires a full negation of one term (e.g., $A \dots B, B \dots \neg A$ or $A \dots \neg B, \neg B \dots A$) or of one full predication (e.g., $(A \dots B) \dots \neg(B \dots A)$). Rather, it is the notational equivalent of what Harris [101, 107] calls an antimetaptoton, a recently identified chiasmic figure in which at least one of the relevant terms has different morphology; in this case, a negation affix. For example, **if someone is happy then they are unbalanced and if someone is balanced then they are unhappy**. The functions associated with antimetaptoton have not been adequately researched. Although Example 3.4.7 resembles the form of an antimetaptoton, it can still be treated as an antimetabole by regrouping the connective symbols $\rightarrow$ and $\neg$ together. If we abuse the notation and define an arbitrary relation **if-then-not** such that:

$$\text{if-then-not}(A, B) \equiv A \rightarrow \neg B$$

Thus, the reciprocal relation conveyed is the **if-then-not** relation between A and B .

$$\text{if-then-not}(A, B) \wedge \text{if-then-not}(B, A)$$

Note that $\text{if-then-not}(A, B) \equiv \text{if-then-not}(B, A)$ since $(A \rightarrow \neg B) \equiv (B \rightarrow \neg A)$, and can be reduced to $\neg(A \wedge B)$. Therefore, Example 3.4.7 basically repeats $\neg(A \wedge B)$ in different directions, one starts from A and ends at B , one starts from B and ends at A . The function of *completeness* [99] is evoked by the antimetabole in the sense that: doesn't

matter where you start, whether you think you have a solution or you comprehend the problem, a solution does not exist.

$$\text{if-then-not}(A, B) \equiv \neg(A \wedge B) \equiv \text{if-then-not}(B, A)$$

I will abuse the notation once again to resemble the form of an antimetabole in the following expression, and let $\text{if-then-not} = r$, $r(A, B) = A r B$ and $\neg(A \wedge B) = \text{goal}$:

$$A r B \equiv \text{goal} \equiv B r A$$

An antimetabole usually conveys arbitrary relations R_1 and R_2 between A and B , with a possibility to collocate with a mesodiplosis to suggest that $R_1 = R_2$. Recall [Formula 3.4.1](#) with an abstract binary connective $*$. In some cases $*$ is explicit as in Newton's Third Law of Motion, or in other cases it is implicit as in [Example 2.1.1](#) and [Example 3.4.7](#).

The functions of pokes, or any rhetorical scheme, are best achieved when accompanied by forms that evoke or trigger neurocognitive affinities that harmonize with the functions. Pokes are choices of styles used in a sentence or passage. The use of these rhetorical figures generates a set of attentional effects linked to a number of neurocognitive affinities of human mind such as balance and opposition, and to its core, repetition and position.

3.5 Neurocognitive Affinity: Repetition and Position

Neurocognitive affinities are patterns that human minds tend to respond to naturally, such as repetition, contrast, balance, opposition, symmetry, etc. The forms of poke figures are based on repetitions which trigger the neurocognitive affinities that can be constructed from repetitions at various positions, e.g., balance, opposition, etc.

As stated previously, the form of an antimetabole, i.e., $\dots A \dots B \dots B \dots A \dots$ triggers a reversed repetition of A and B that resembles a balanced structure similar to the opposite arrows in [2.9](#). Harris [\[99\]](#) describes the neurocognitive affinity of reversed repetition from the view of diagrammatic iconicity in the sense of a reciprocal energy flow [\[137\]](#), which maps to the image schema of point balance [\[116\]](#) as shown in [Figure 3.5a](#). Another view is that the form of antimetabole is chiasmic (a shape that resembles the Greek letter χ) which again is a balanced structure [\[100\]](#) as shown in [Figure 3.5b](#). Another example is the form of anadiplosis, i.e., $\dots A, A \dots$. The repetition occurs on both sides of the boundary of

proximal clauses generates a focus point (see Figure 3.5c) that captures a reader’s attention [23]. This focus point often serves as a transition point of a step-wise energy flow as shown in Figure 3.5d. The repetition at the final position of the boundary acts as the semantic role GOAL of the first clause, then the repetition at the initial position of the successive clause acts as the SOURCE of that clause [99].

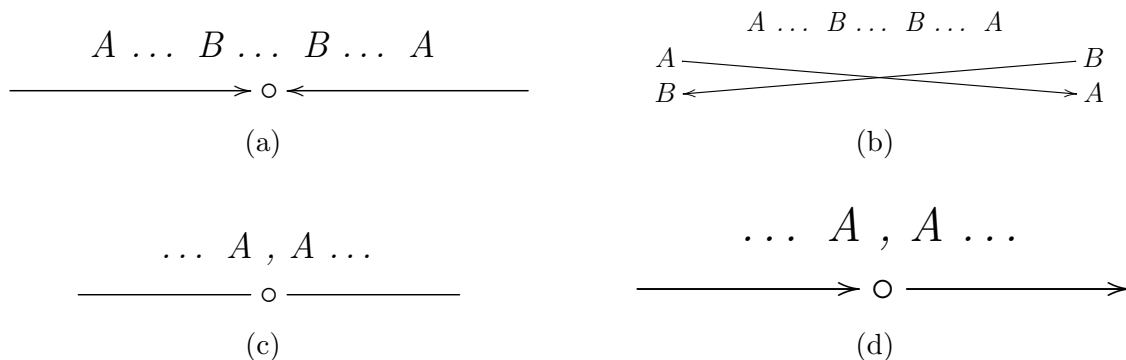


Figure 3.5: The form of antimetabole triggers (a) a point balance structure; (b) a chiasmic structure. The form of anadiplosis triggers (c) a focus point; (d) a step-wise energy flow. Modified based on [99, 100, 116].

3.5.1 Collocation and Language Independence of Ploke

Neurocognitive affinities such as balance, opposition, etc. are often the results of multiple rhetorical figures working together [100]. These neurocognitive affinities are triggered at the same time when multiple ploke figures are present in the same passage as in Example 2.1.1.

Example 2.1.1 is an antimetabole, but it also contains a number of other figures such as anadiplosis, mesodiplosis, and epanalepsis as demonstrated by Harris et al. [96, 106].

Anadiplosis: the repetition of a lexeme or lexical groups on either side of a clause or phrase boundary.

All for one, one for all.

Antimetabole: the proximal occurrence of the same two lexemes or lexical groups in reverse order.

All for one, one for all.

Epanalepsis: lexical repetition at the beginning and ending of a phrase or clause [96].

All for one, one for all.

Mesodiplosis: the occurrence of the same lexeme or lexical group in the middle of proximal clauses or phrases.

All for one, one for all.

Harris [96] discusses how each figure contributes to the aesthetic effect of [Example 2.1.1](#) and facilitates the function of epitomizing reciprocity, specifically, reciprocal obligation. Mesodiplosis creates points of balance in both clauses that highlighted a symmetrical structure in the sentence in which brings a sharper focus to the reciprocal relationship expressed in the two instances of the preposition, i.e., **for**. Anadiplosis and epanalepsis, although largely submerged in instances with antimetabole, each functions with its own purpose. Harris observes that anadiplosis is able to “focalize a word that has been a bit of a bystander in the previous phrase or clause; or, in Peacham’s terms, ‘to add a certain increase in the second member’” [96]. In [Example 2.1.1](#), the first occurrence of **one** may refer to a person that passively benefits from the obligations of the group, but becomes an active contributor in the second occurrence, now taking on an obligation toward the group. On the other hand, epanalepsis “promote[s] some property of a crucial term in the expression” [96]². [Example 2.1.1](#) begins and ends with the group, i.e., **all**, which promotes the property of collectivity.

Recall the opposite arrows in [Figure 2.9](#). The opposite arrows trigger the neurocognitive affinities such as opposition and balance, making the area more salient than the other shapes. The plope figures exhibit the same effect. The collocations of plokies in [Example 2.1.1](#) trigger the same harmonized effect of opposition and balance. Specifically, the form of the antimetabole triggers the opposite point balance structure as shown in [Figure 3.5a](#). The form of the mesodiplosis triggers another balanced structure that pinpoints the opposition and balance structure triggered by the form of the antimetabole. Epanalepsis creates a boundary at each end of the passage which encapsulates and further solidifies the balanced structure.

²Figures like parison (syntactical structure repetition) and isocolon (syllable repetition) also play important parts in this instance as discussed in [96]

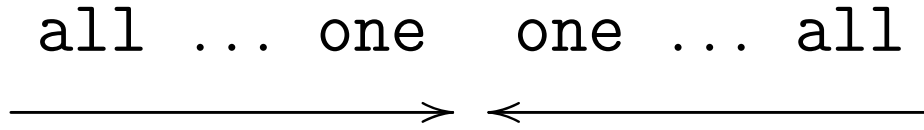


Figure 3.6: The antimetabole in [Example 2.1.1](#) resembles the opposite balance neurocognitive affinity.

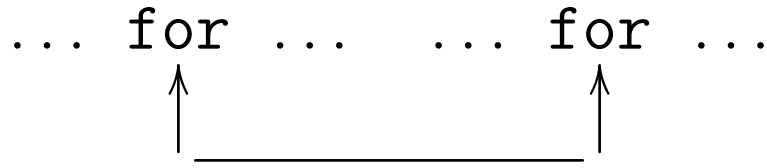


Figure 3.7: The mesodiplosis in [Example 2.1.1](#) pinpoints the balance neurocognitive affinity.

Note that these patterns are formed purely based on the syntactic form, i.e., by the repetition of the words. One can still get a sense of the salience and other attentional effects without being able to process the semantics or context as shown in [Figure 3.10](#). Therefore the attentional effects of pokes are independent of language.

Traditionally, neurocognitive affinities are viewed as entities independent from each other. However, as demonstrated above, the forms of pokes do not trigger neurocognitive affinities such as balance and opposition directly, but contribute through combinations of orientations of repetitions at various positions. The opposite balanced structure is gone once the repetitions are removed as shown in [Section 3.5.3](#). That is, repetition and position are the primary neurocognitive affinities triggered by the form of a poke.

3.5.2 Position

Position is an entity that determines the specific orientation of a repetition. Position specific repetitions form various structures depicted by neurocognitive affinities when a word or phrase repeats at different positions within a clause. In this sense position can be considered as a type of neurocognitive affinity.

In the scope of poke, a position can be classified respective, relative, or unpatterned. A respective position describes the position of a word or word group when it repeats at a position with respect to another word or word group, e.g., a respective position can be immediately followed or preceded by another position as in an epizeuxis, reversed as in an

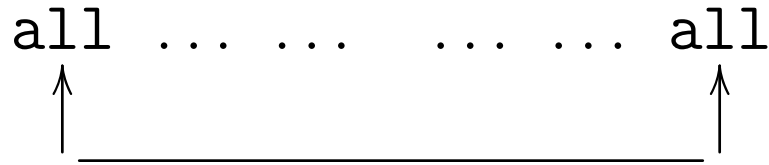


Figure 3.8: The epanalepsis in [Example 2.1.1](#) creates boundaries at both ends to solidify the balanced structure.

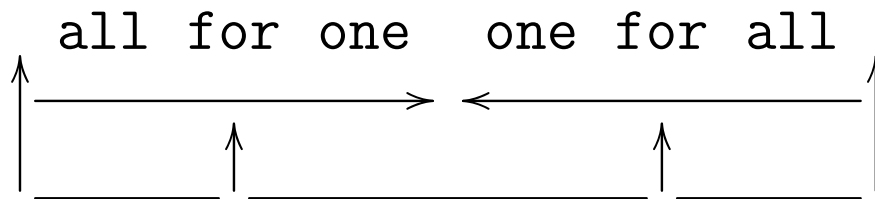


Figure 3.9: The collocation of antimetabole, epanalepsis, and mesodiplosis in [Example 2.1.1](#) generate the harmonized salience effect.

antimetabole, or proximal with respect to another token in a passage; A respective position describes the position of a word or word group when it repeats at different positions within a phrase or clause, e.g., a position can be the initial, medial, or final position with respect to a clause with in a passage; Otherwise, a position can be classified as a unpatterned position. A more detailed description on the ontological representation of position and its subclasses can be found in [Chapter 4](#).

3.5.3 Repetition

Repetition is an important and fundamental aspect of language and cognition. It is possibly the most fundamental neurocognitive affinity that builds the foundation of brain activities and thus human minds [\[99\]](#). Repetition emphasizes and stabilizes a sequence in memory and thus is essential for memorization. Most people tend to repeat a formula or a phone number in order to remember it [\[104\]](#). Ploke is the repetition of a word or word group. In terms of attentional effects of ploke, it is the repetitions that generate the salience effect on the repeated word or word group. That is, the more a word or word group repeats, the more noticeable it becomes, and thus the concept conveyed by that the word or word group becomes more memorable [\[99\]](#). Harris [\[99\]](#) states that:

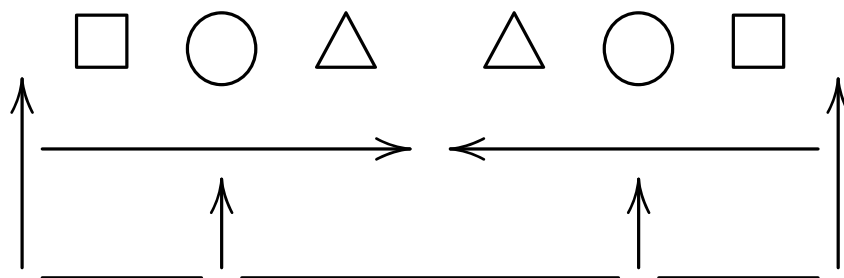


Figure 3.10: The same salience effect can still be interpreted without semantic information.

All discussion of brain activity must start in some way with repetition. Brains operate on a basal substrate of repetition. Neurons fire repetitively. Neural pathways build up through repetitions of the same firing patterns. Saying words over and over, as children do, builds up the motor cortex patterns and the form/meaning association patterns necessary to say, as well as to understand, words [99].

Repetition of a word or phrase in a passage or speech emphasizes the concept it conveys and stabilizes the reference to increase its clarity in context, which are functions of plope. The use of plope thus emphasizes the ideas that are being transferred. Due to the importance of repetition, Harris argues that plope is a scheme that is fundamental to language and thought. Its importance is no less than metaphor to tropes [94, 99].

Again, I will use antimetabole as an example. The form of antimetabole demonstrates a balanced structure with the reversed repetition of *A* and *B*, therefore triggering neurocognitive affinities of a reversed repetition which in turn contributes to affinities such as balance and opposition. Harris et al. states how repetition plays an important role in the figure antimetabole: “At the deepest operational levels of the brain, there are repetitions of neuronal-population firing patterns, reflected at the level of cognition by the importance of repeated stimuli. Antimetaboles have a double repetition” [106]. The “double repetition” mentioned is frequently enhanced by the harmonized attentional effect generated by different rhetorical figures working conjointly as shown previously. An antimetabole is not only memorable due to its double repetition, it is also aesthetically pleasing and memorable as it also deploys neurocognitive affinities of balance and opposition which are enhanced by other rhetorical figures involved. The aesthetic and salience effects created by the combination of various repetitions from the presence of plokes make the statements more aesthetically pleasing, easier to recognize and remember, such as Example 2.1.1 [110].

Harris [96] produces a rephrased instance of [Example 2.1.1](#) in which all plope figures listed above are eliminated except for the antimetabole.

all in the service of one, at the same time as one serves
the interests and success of all. [96] (Example 3.4.8)

Without the contributions of the other figures such as mesodiplosis, [Example 3.4.8](#) exhibits the function of reciprocal obligation but not as obviously as [Example 2.1.1](#). Although some may argue that it is more precise by making explicit the role of “in the service of” and “serves the interests”, it is certainly much more cumbersome and less memorable than [Example 2.1.1](#) [96]. The following instance is an attempt to remove all lexical repetition figures:

A group in the service of its members, at the same time
as an individual advances the interests and success
of the entire community. (Example 3.4.9)

Note that rhetorical figures still exist in [Example 3.4.9](#) since figures are linguistically inescapable. Repetitions still exists semantically since a reader is able to connect **group** to **community** and **members** to **individual**³. Although the same idea can be conveyed, the reciprocal relationship becomes even less obvious. The form is no longer supporting the notion of reciprocity. It is actively hindering it. [Example 3.4.9](#) loses the salience, aesthetic pleasure and memorability of [Example 2.1.1](#). It is difficult to imagine readers preferring to quote [Example 3.4.9](#) over the simpler and cleaner [Example 2.1.1](#). Certainly [Example 3.4.9](#) is much more difficult to remember and is far less salient than [Example 2.1.1](#). Of course, both [Example 3.4.8](#) and [Example 3.4.9](#) are longer and the chiasitic structures of the antimetaboles are not as obvious as the original [Example 2.1.1](#). Length is indeed a direct impact on memorability of a passage but the focus here is the impact of the form of the antimetaboles and in turn the repetitions have on the attentional effects generated by these passages. A string with antimetabole embedded, e.g., **abccba**, generates different attentional effects compared to an arbitrary string, e.g., **htxprm**, even when the passages have the same length.

³The utterance exhibits the figure of *periphrasis*, the use of excessive words to convey a shorter expression. The repetitions of sememe of **member/individual** and **group/community** are examples of the rhetorical figure *synonymia*.

However, it is still an open question how the form/function pairing correlates each other. For example, do antimetaboles always produce reciprocity when transitive verbs are used between the reversed terms, i.e., when there is a mesodiplosis of the same transitive verb [107]? Further discussion is out of the scope of this thesis but readers may refer to Harris [101, 102] for explanation from a perspective that utilizes Construction Grammar (CxG) [108]. A more general question is how the amalgamation of form/function pairings of rhetorical figures triggers the neurocognitive affinities which in turn generate attentional effects. The next section discusses the attentional effects plope figures can generate, such as salience, aesthetic pleasure, and mnemonic effect.

3.6 Attentional Effects

Salience is the quality of attracting one's attention. Rhetorical figures generate effect on salience of a passage or utterance by triggering neurocognitive affinities. Plope, in particular, generates salience effect through repetition.

Recall that salience effect can be demonstrated through the foreground-background (figure-ground) relation. The existence of plope figures distinguishes the foreground and background in a passage. Example 3.4.10 from President Obama contains anadiploses which act as the foreground, in which the rest of the text as background.

One voice can change a room.
 And if it can change a room, it can change a city.
 And if it can change a city, it can change a state.
 And if it can change a state, it can change a nation.
 And if it can change a nation, it can change a world. [176] (Example 3.4.10)

In Figure 3.11, the dark triangle acts as a foreground against the light rectangle as background⁴. The analogy is that the repetition in an anadiplosis, referred as the element of anadiplosis by Black et al., acts as the foreground, i.e., the dark triangle, while the remainder of the text acts as the background, i.e., the rectangle [23]. Of course, the

⁴Note that it is natural to view the background as a complete rectangle rather than two trapezoids on both sides of the dark triangle. This is due to the Gestalt principle of continuity which is discussed further in Black et al. [23].

salience and persuasive power of this quote is the result of a combination of rhetorical figures of both schemes, i.e., anadiplosis and gradatio, and tropes, i.e., incrementum which is characterized by the semantic increase in a series of words, and climax, which is the combination of gradatio and incrementum.



Figure 3.11: Perceptual foregrounding, adapted from Black et al. [23]. Modified based on Rubin [199].

A gradatio is a series of anadiploses. In the example above each repetition of the anadiploses acts in turn as a separate foreground while blending the other repetitions, as well as the remainder of text, into the background of text. As stated by Black et al. [23].

Anadiploses are a more tightly-bound figure linked together by the larger underlying [g]radatio. In this way, each [a]nadiplosis is foregrounding itself from the text, and the [g]radatio is foregrounding it at the level of figuration. This compound foregrounding acts both on the level of cognition and semiosis. The repetition of the words in the [a]nadiplosis draws attention and the repeated repetitions further signifies the importance of these repeating elements. In this way the brain is unconsciously drawn to these elements evoking an enhanced meaning from each beyond the level of each figure acting independently.

In Example 2.1.1, the aesthetic effects generated by the repetition and reversal of the words, which form the harmonized opposite and balanced structure as shown in Figure 3.9, make the statement more aesthetically pleasing to a reader and easier to remember, and thus became a famous quote [110]. The increase of memorability is another attentional effect triggered by neurocognitive affinities associated with plokets and schemes in general such as repetition, proximity, position, balance, etc. The attentional effects caused by the form of schemes can have diagnostic purposes to detect and identify cognitive conditions and cluster of syndromes such as dementia, which impairs cognitive functions of an individual in daily life [98]. Alzheimer’s disease is a type of dementia. Individuals diagnosed with dementia often speak in “formulaic language” [98]. Meaning and lexical relations are particularly difficult for people with dementia. The forms of language support the fight against cognitive decline, and schemes are rhetorical figures characterized by their forms. Harris [98] provides examples on how such “formulaic language” contains rhetorical figures that

made the “formulaic language” more memorable, thus more resilient to dementia. Harris also emphasizes the effects generated by schemes with forms that trigger neurocognitive affinities such as sequential contrast and acoustic symmetry, as well as repetition, the most basic neurocognitive affinity. Repetition, sequential order, and position are neurocognitive affinities triggered by plope figures that are still recognizable for individuals diagnosed with dementia. Individuals diagnosed with dementia speak frequently using repeated terms or structures. Thus detecting repetitions, which in turn detects plokcs, could aid the detection of dementia. Harris provides two examples of language spoken or written by two individuals diagnosed with dementia. One of which is a speech error, while the other is a poem written by a poet with dementia. Both examples are instances of epanaphora, a subtype of plope.

I say to my wife
I say in here
 and I can’t think of words [158].

Harris explains that the example above is a “disjointed planning error, of the sort we are all capable of committing now and again. But the scale goes way up in dementia” [98]. However, it is still an epanaphora. The example below is a more artistic epanaphora from poet Kate Swaffer, written after being diagnosed with dementia [168]. It also features mesodiplosis.

Lost my teddy
 Lost my book
 Lost my keys
 Lost my bird
 Lost my love
 Lost my way
 Lost my mind
 Lost my soul [210]

Both examples show that repetition plays a critical role in cognitive resilience. This work of Harris highlights the fact that repetition as a neurocognitive affinity is fundamentally wired in human minds. Repetition can still be recognized through language produced by a person even when his/her mind is under an impaired state such as having dementia.

The next chapter proposes a formal KR model for the Plope Ontology.

Chapter 4

The Ploke Ontology

This chapter proposes a formal KR model based on the concepts of Ploke presented in Chapter 3, the Ploke Ontology. Although the term “ontology” is used in the name, the Ploke Ontology is not a conventional OWL ontology. The Ploke Ontology is a knowledge representation of Ploke presented using a combination of Extended-Entity Relationship (EER) diagrams and a pair of table signature and integrity constraints expressed in First-Order Logic (FOL) to define the corresponding EER diagram. This ontology represents the classification of pokes and related knowledge such as form, linguistic features such as tokens involved in a poke, and neurocognitive affinities of various types of pokes, which are various types of repetitions differing in the positions of the repeated elements. There is no unified definition of Ploke and definitions are inconsistent as discussed in Chapter 3. It is vital for the KR model for Ploke to find a balance between capturing knowledge of Ploke and preserving flexibility to accommodate a variety of use cases of Ploke. Therefore the Ploke Ontology serves as a foundation and a blueprint for future implementation of OWL ontologies for Ploke rather than a conventional OWL ontology. Section 4.10 discusses the connection between the Ploke Ontology and established ontology engineering methodologies. The next section provides a procedure for generating an EER model of the Ploke Ontology. Later sections demonstrate the application of the procedure to specific concepts in the Ploke Ontology.

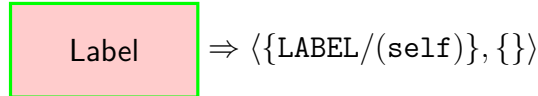
4.1 An EER Model of the Ploke Ontology

This section provides a formal definition of a dialect of EER model similar to Ma et al. [146] and Borgida et al. [25, 26] in terms of a first-order theory $\langle s, c \rangle$ consisting of a table

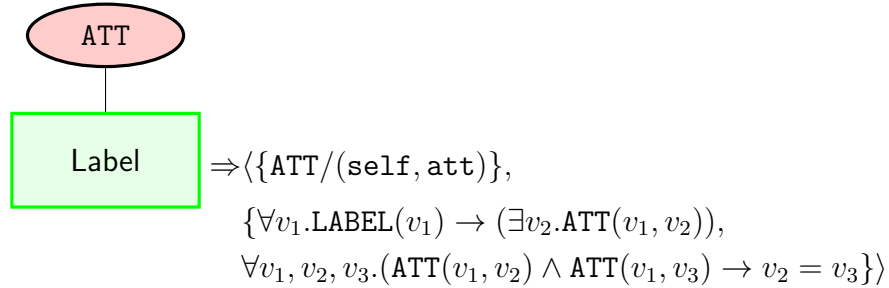
signature s and a finite set of integrity constraints c over the signature. The signature s defines an one-column table for entities, two-columns table for attributes and relations. The constraints c are written in FOL sentences. Each label represents an unique entity set or relation. In any EER diagram in this chapter, the order of entity sets associated with a relation is assumed to be in clockwise order. For example, if a relation R that connects entity sets with labels $Label1$ and $Label2$ respectively, where $Label1$ appears at the top (12 o'clock position) and $Label2$ appears at the bottom (18 o'clock position), then the EER diagram represents the relation $R(Label1, Label2)$.

This section defines a procedure for constructing an ontological model using EER diagrams. First, all components of the EER diagram such as entities, attributes, and relations are initialized with empty pairs $\langle \{\}, \{\} \rangle$ and marked as red. Every red component of the EER diagram is an undefined component. Then for each component of the EER diagram, a pair $\langle s, c \rangle$ is assigned incrementally and is marked green. Every green component of the EER diagram is a defined component. The pair $\langle s, c \rangle$ assigned to each new undefined component of the EER diagram is the additional signature and constraints corresponding to the current red component and assume all green components are defined previously. FOL formulae will be used occasionally to support the explanation of concepts within the ontology. Entity sets in s will be in Typewriter font with full capitals, e.g., LABEL. Integrity constraints c is written in FOL sentences with entity sets and variables.

Entity Set

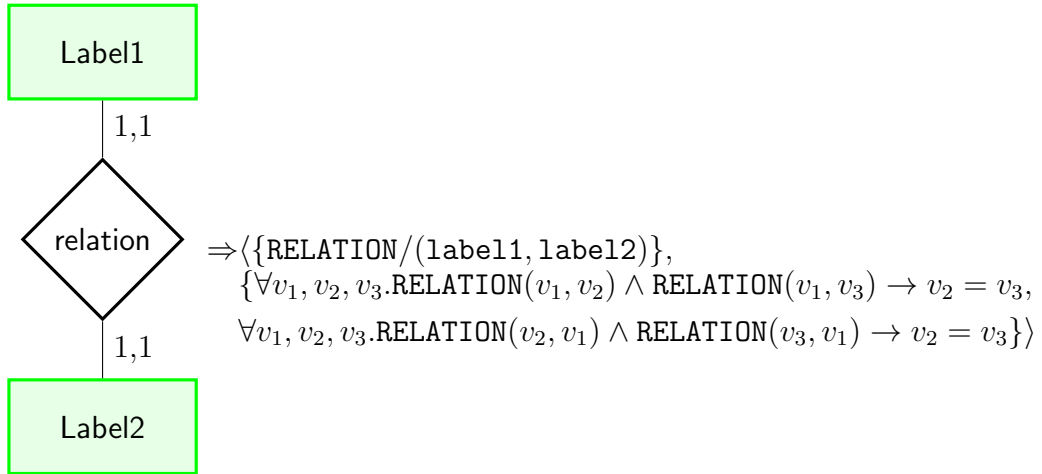
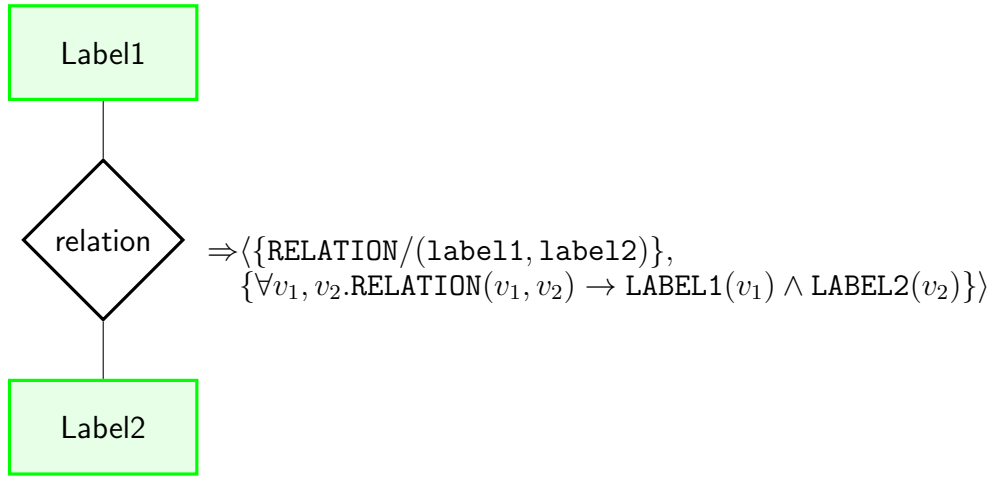


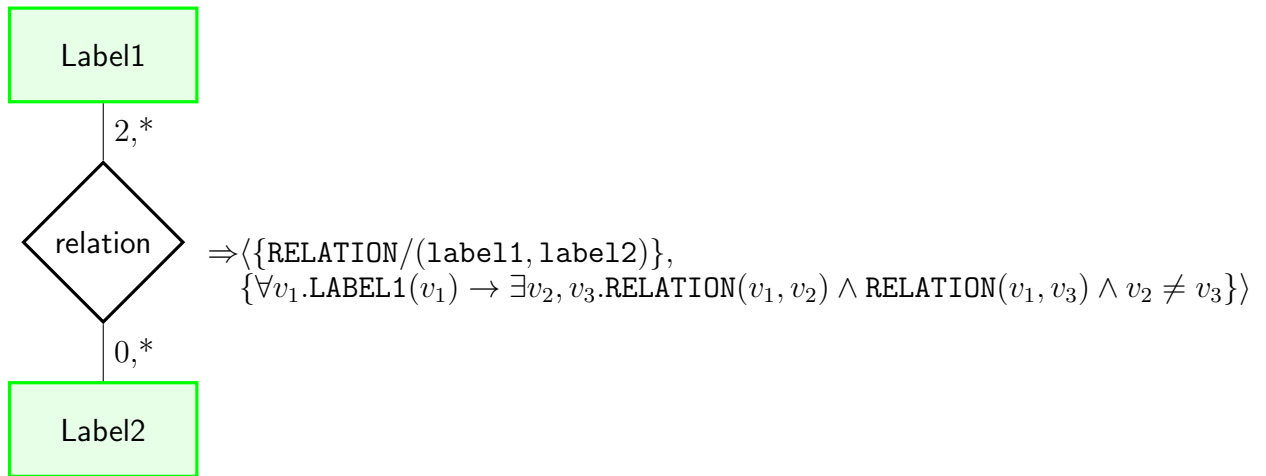
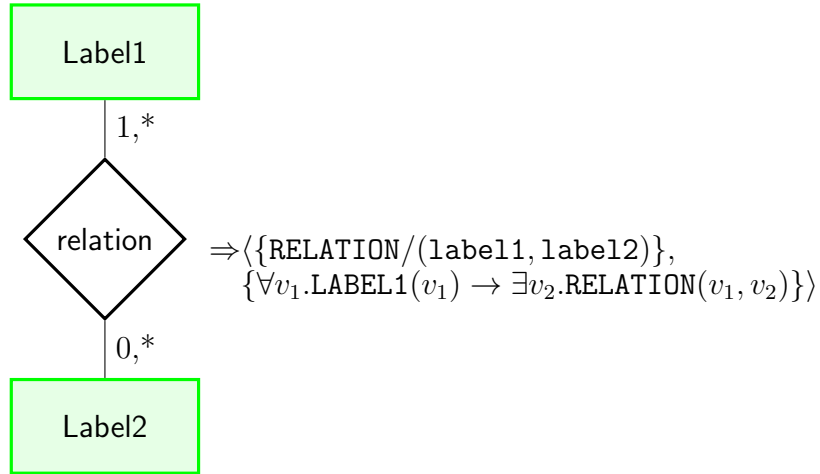
Attribute



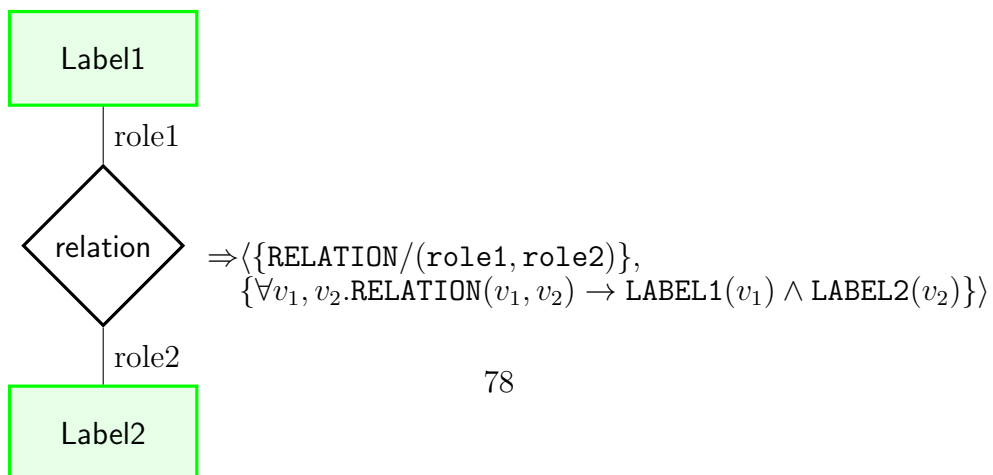
Binary Relationship Set

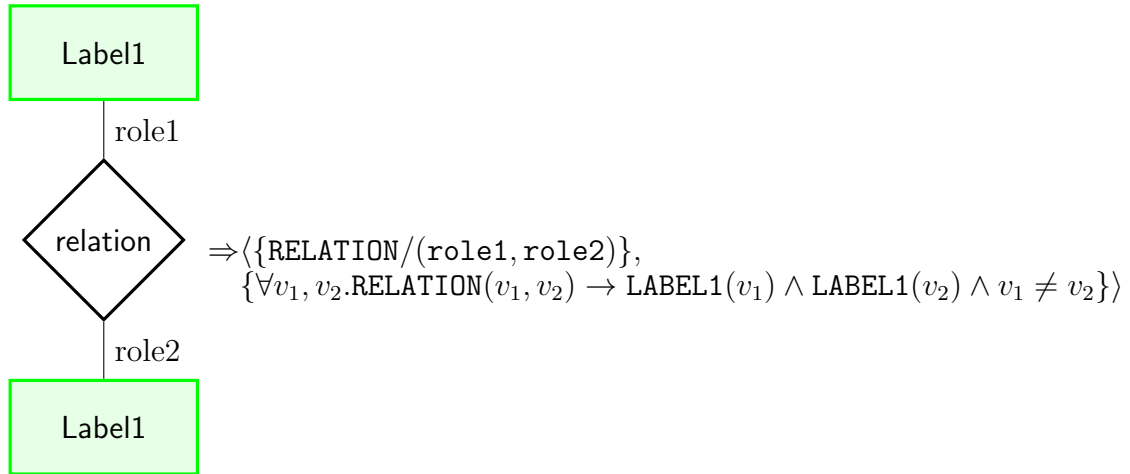
Assume all *Label1* and *Label2*, etc. are distinct entities. That is,
 $\forall v_1. \text{LABEL2}(v_1) \rightarrow \neg \text{LABEL1}(v_1)$



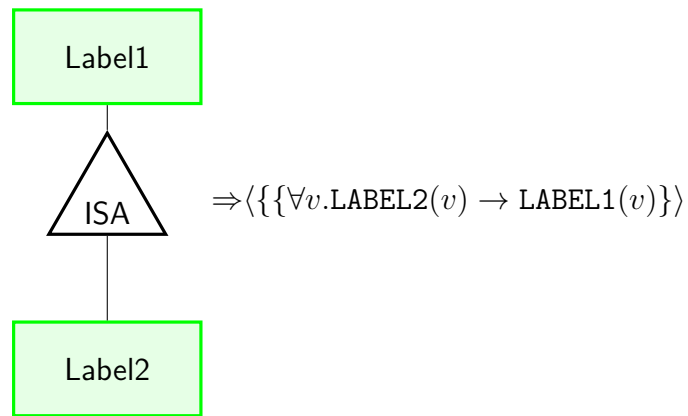


Role Names

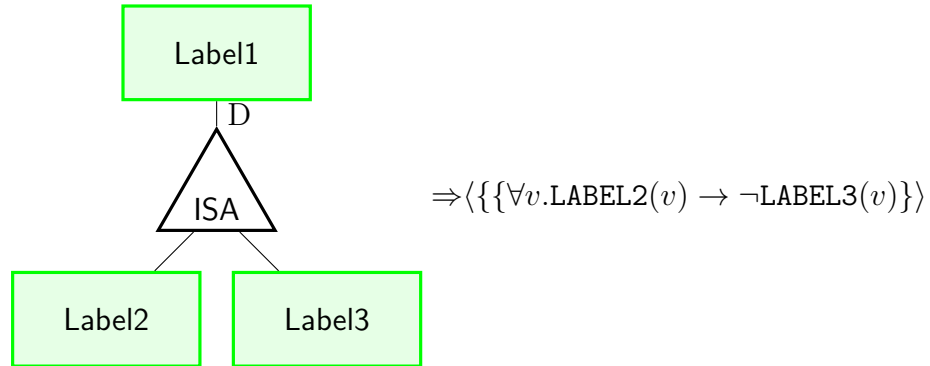




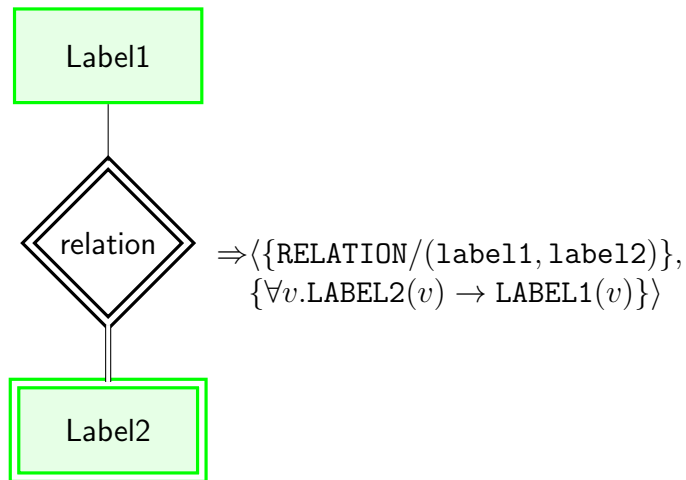
ISA



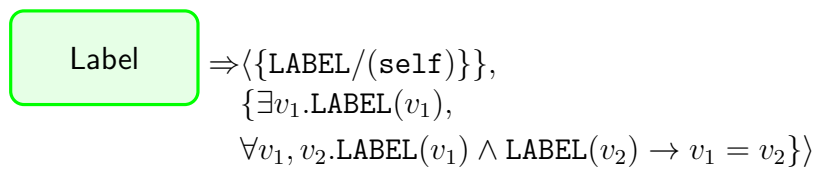
Disjoint



Weak Entity Set



Nominal



4.2 The Ploke Ontology: General Level

This section describes the general level concepts of rhetorical figures in the Ploke Ontology, including classification of rhetorical figures as well as related concepts such as linguistic elements, neurocognitive affinities and attentional effects. The concepts in this general level are not intended to be comprehensive but rather as a collection of upper level classes and relations that encapsulate concepts of ploke presented in the next section. This chapter uses a capitalized word in a Sans serif font to indicate a class name, e.g., **Ploke**; an uncapitalized word in Sans serif font to indicate a relation, e.g., **contains**; a Typewriter font for an example quotation of a rhetorical figure or a part thereof, e.g., **all for one**; and slanted Typewriter font for denoting an arbitrary instance of a class, e.g., *passage1*. Occasionally a path notation $r1.r2.r3 \dots rn$ will be used to denote a path of relations, e.g., $r1.r2(X, Z) \leftrightarrow r1(X, Y) \wedge r2(Y, Z)$.

4.2.1 The Neurocognitive Path in Ontological Terms

To the center of the ontology is the class **Rhetorical Figure**. A **Rhetorical Figure**, contained (contains) in a **Passage**, causes the **Passage** to have **Attention Effects** on the **Passage's Receiver**, as is shown by the bold path in Figure 4.1. This is the aforementioned neurocognitive path of rhetorical figures. The goal is to formally represent concepts along this path.

Scheme and **Trope** are the two subclasses of **Rhetorical Figure**. I did not include **Chroma** and **Move** for simplicity. The class **Ploke** is a subclass of **Scheme**.

Chapter 3 distinguished the concept of simple ploke and complex ploke. Since there is only one subclass in simple ploke, the taxonomy can be flattened. A class is created by each of the subclasses of **Ploke**: **Anadiplosis**, **Antimetabole**, **Conduplicatio**, **Epizeuxis**, **Epanalepsis**, **Epanaphora**, **Epistrophe**, **Gradatio**, **Mesodiplosis**, etc.

A **Rhetorical Figure** consists of a **Form** and a **Function**¹. The **Form** of a **Rhetorical Figure** consists of a set, possibly ordered, of **Linguistic Elements**. A linguistic element one of a word, syllable, phrase, clause, phoneme, lexeme, morpheme, sememe. The class **Linguistic Elements** can be classified into **Scheme LE** and **Trope LE**. Since this thesis focuses on ploke, I will omit details of other linguistic elements and focus the discussion on **Token** only, which is defined in this thesis as one word or a sequence of words, minimally interrupted. **Token** is a subclass of **Linguistic Elements**. Another subclass of **Linguistic Element** is **Clause**, which refers to a clause in a **Passage**.

¹Also referred to as *rhetorical function*

The Form of a Rhetorical Figure triggers one or more neurocognitive affinities. A Neurocognitive Affinity is a pattern recognized by a receiver's brain [106], e.g., Symmetry, Balance, Opposition, Position, Repetition, Semantic Opposition, etc. These neurocognitive affinities, individually or conjointly, will generate Attention Effects such as salience, aesthetic pleasure, or increase memorability [106].

Recall that the connection made by the neurocognitive affinities creates a coupling between a rhetorical figure's form and its function. The function becomes predicable when the form of a rhetorical figure is recognized [106]. For example, lexical repetition of the tokens **all**, **for** and **one** in Example 2.1.1 functions to stabilize reference for the concept conveyed to ensure that **all** and **one** refer to the same entities [67]. The reversed repetition triggered by the form of the antimetabole in Example 2.1.1 generates a focus on the reciprocal relationship [67]. The reversed repetition in Example 2.1.1 resembles a balance of structure, an opposition of **all** and **one**, etc. each of which is a neurocognitive affinity that human minds tend to capture easily. All figures present in Example 2.1.1 harmoniously generate attentional effects such as salience, aesthetic pleasure, and memorability, thus a famous quote was created [100]. There are other rhetorical figures such as parison and isocolon that contribute to the attentional effects of Example 2.1.1.

Since a Rhetorical Figure consists of a Form and a Function, Ploke as a subclass of Scheme which in turn is a subclass of Rhetorical Figure, inherits this property. The form of a ploke, i.e., PlokeForm, a subclass of Form, triggers a set of subclasses of Neurocognitive Affinity such as Repetition, Position, Balance, Opposition, etc. Each subclass of Ploke has a specific form which triggers a set of neurocognitive affinities. Repetition is the core neurocognitive affinity represented by the Ploke Ontology.

According to Harris [99], repetition is a neurocognitive affinity that human minds tend to capture easily. It's considered to be one of the neurocognitive affinities triggered by forms of ploke figures among other neurocognitive affinities such as symmetry, balance, opposition, etc. Observe that the aforementioned neurocognitive affinities triggered by ploke forms are compound patterns or structures with repetitions and positions as basic building blocks. In other words, these neurocognitive affinities are formed by repeating a token at various positions.

4.3 Rhetorical Figure Level

4.3.1 Rhetorical Figure

The Rhetorical Figure class is defined as below. A general assumption is that every entity has a corresponding id. The EER diagram is shown in 4.2.

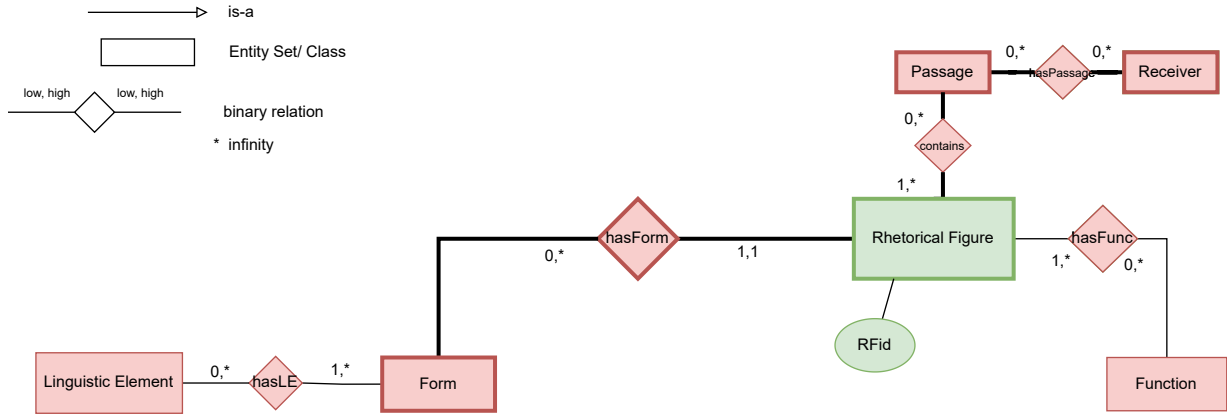


Figure 4.2: Rhetorical Figure entities

$$\text{RhetoricalFigure} \Rightarrow \langle \{ \text{RHETORICALFIGURE} / (\text{self}) \}, \{ \} \rangle$$

$$\begin{aligned} \text{RFid} \Rightarrow & \langle \{ \text{RFID} / (\text{self}, \text{rfid}) \}, \\ & \{ \forall e. \text{RHETORICALFIGURE}(e) \rightarrow (\exists v. \text{RFID}(e, v)), \\ & \forall v_1, v_2. (\exists e. \text{RFID}(e, v_1) \wedge \text{RFID}(e, v_2) \rightarrow v_1 = v_2) \} \rangle \end{aligned}$$

4.3.2 Form

The remainder of this chapter assumes all entities are defined as below and has an id attribute that is not shown on the EER diagram. The EER diagram is shown in 4.3

$$\text{Form} \Rightarrow \langle \{ \text{FORM} / (\text{self}) \}, \{ \} \rangle$$

hasForm $\Rightarrow$

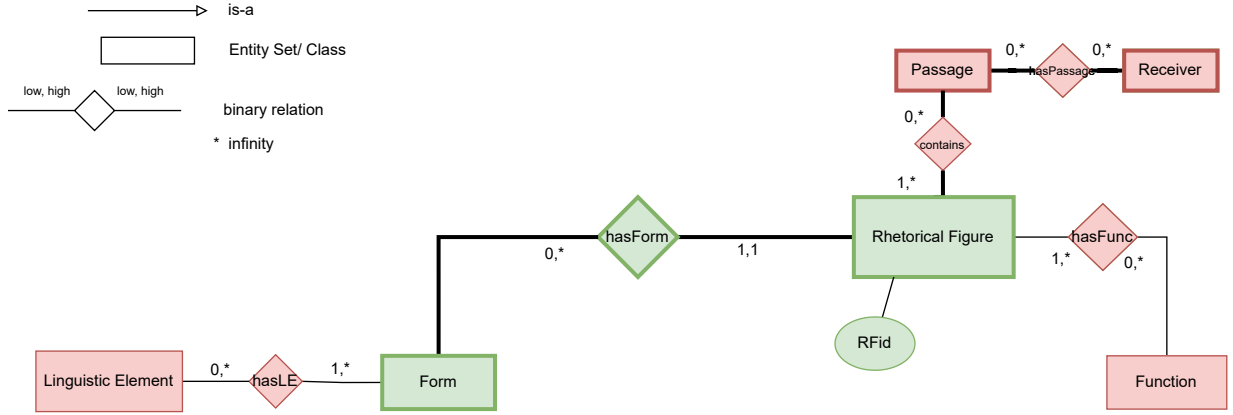
$$\langle \{ \text{HASFORM}/(\text{rhetoricalfigure}, \text{form}) \}, \\ \{ \forall v_1, v_2. \text{HASFORM}(v_1, v_2) \rightarrow \text{RHETORICALFIGURE}(v_1) \wedge \text{FORM}(v_2), \\ \forall v_1, v_2, v_3. \text{HASFORM}(v_1, v_2) \wedge \text{HASFORM}(v_1, v_3) \rightarrow v_2 = v_3 \} \rangle$$


Figure 4.3: Defined Rhetorical Figure entities

4.3.3 Linguistic Element

Linguistic Element $\Rightarrow \langle \{ \text{LINGUISTICELEMENT}/(\text{self}) \}, \{ \} \rangle$

$$\text{hasLE} \Rightarrow \langle \{ \text{HASLE}/(\text{form}, \text{linguisticelement}) \}, \\ \{ \forall e_1. \text{FORM}(e_1) \rightarrow \exists e_2. \text{LINGUISTICELEMENT}(e_2) \wedge \text{HASLE}(e_1, e_2) \} \rangle$$

4.3.4 Scheme

$$\text{Scheme} \Rightarrow \langle \{ \text{SCHEME}/(\text{self}) \}, \\ \{ \forall e. \text{SCHEME}(e) \rightarrow \text{RHETORICALFIGURE}(e) \} \rangle$$

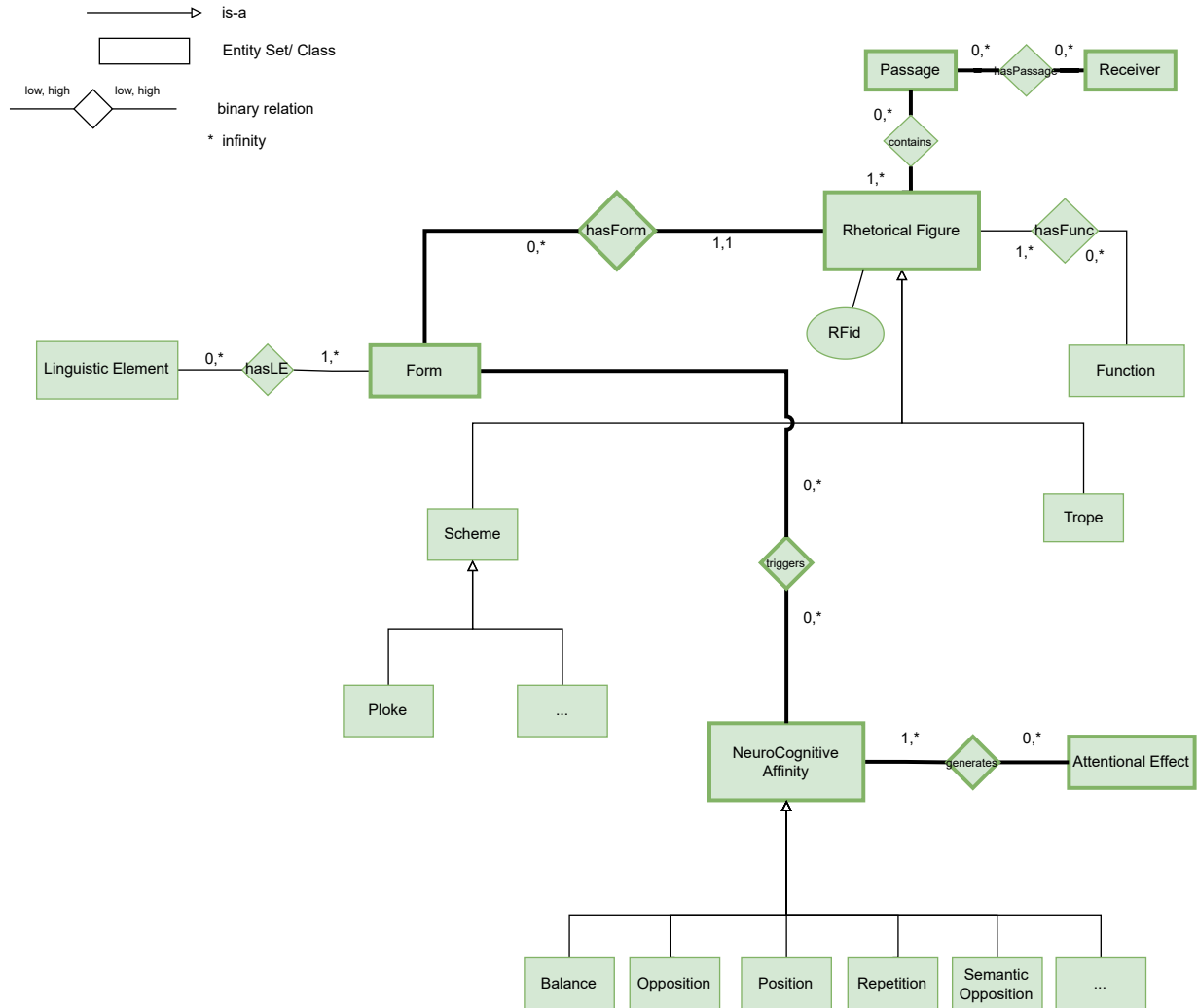


Figure 4.4: Defined general level entities

The remaining entities and relations are all defined in similar manner where green entities and relations are defined. Only additional constraints are shown in definitions below. Some obvious isa relations are not shown for simplicity, e.g., **PlokeForm** is a subclass of **Form**. All entities and relations in EER diagrams beyond this point are assumed to be green after their definitions are shown.

4.4 Ploke Level

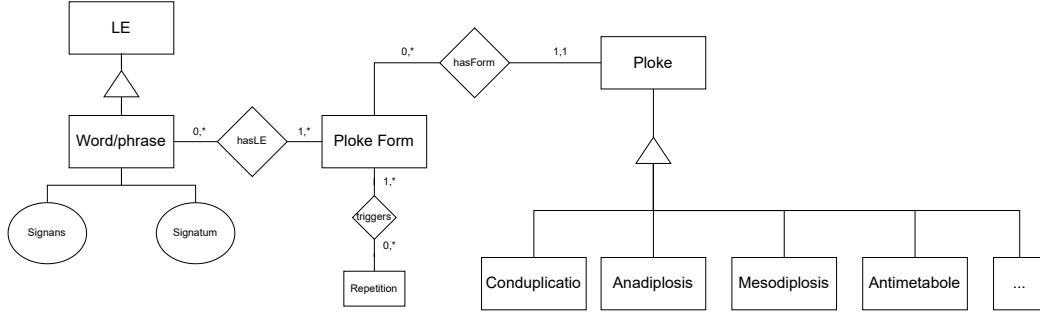


Figure 4.5: Ontological view of Ploke

Ploke

$$\begin{aligned} \text{Ploke} \Rightarrow & \langle \{ \text{PLOKE} / (\text{self}) \}, \\ & \{ \forall v_1. \text{PLOKE}(v_1) \rightarrow \exists v_2. \text{PLOKEFORM}(v_2) \wedge \text{HASFORM}(v_1, v_2) \} \rangle \end{aligned}$$

PlokeForm The class **Word/phrase** can be used to extend the Ploke Ontology to be used with other rhetorical figure ontologies. It contains information of both signans and signatum. In this thesis the class **Word/phrase** is reduced to **Token** in which the same instance of **Token**. See Section 4.5.

$$\begin{aligned} \text{PlokeForm} \Rightarrow & \langle \{ \text{PLOKEFORM} / (\text{self}) \}, \\ & \{ \forall v_1. \text{PLOKEFORM}(v_1) \rightarrow \exists v_2. \text{WORD/PHRASE}(v_2) \wedge \text{HASLE}(v_1, v_2) \} \rangle \end{aligned}$$

hasForm This is a specialized **hasForm** that connects **Ploke** and **PlokeForm**. Can be renamed to e.g., **hasPlokeForm**, which is a subproperty of **hasForm** to distinguish from **hasForm** introduced for Rhetorical Figure and Form.

$$\begin{aligned} \text{hasForm} \Rightarrow & \\ & \langle \{ \text{HASFORM} / (\text{ploke}, \text{plokeform}) \}, \\ & \{ \forall v_1, v_2. \text{HASFORM}(v_1, v_2) \rightarrow \text{PLOKE}(v_1) \wedge \text{PLOKEFORM}(v_2), \\ & \forall v_1, v_2, v_3. \text{HASFORM}(v_1, v_2) \wedge \text{HASFORM}(v_1, v_3) \rightarrow v_2 = v_3 \} \rangle \end{aligned}$$

triggers

$$\begin{aligned} \text{triggers} \Rightarrow \langle \{ \text{TRIGGERS}/(\text{plokeform}, \text{repetition}) \}, \\ \{ \forall e_1, e_2. \text{TRIGGERS}(e_1, e_2) \rightarrow \text{PLOKEFORM}(e_1) \wedge \text{REPETITION}(e_2), \\ \forall e_1. \text{PLOKEFORM}(e_1) \rightarrow \exists e_2. \text{TRIGGERS}(e_1, e_2) \wedge \text{REPETITION}(e_2) \} \rangle \end{aligned}$$

Note that **triggers** is also a binary relation between the more general classes **Form** and **Neurocognitive Affinity**.

4.5 Token

A token is the basic lexical unit being repeated. It can be a word or phrase, etc. A token consists of a syntactical form, i.e., signans, and the semantic meaning, i.e., signatum. In this thesis we do not elaborate the representation of syntactical form and semantic meaning. It is assumed the syntactical form and semantic meaning are the same for a specific instance t of the class **Token**.

The users of the ontology can defined what lexical units are defined as a token. In this thesis we consider the case in which a token is a word or phrase. However, this ontology leaves freedom to represent more granular lexical units such as lexeme and morpheme which are essential to develop representations for rhetorical figures such as polyptoton. For a specific passage, the representation of plope may be different when different tokens are considered. For example, a token of a string `abcdabc` can be either ‘a’, ‘b’, or ‘c’, `ab`, `bc`, or `abc`, etc. Repetitions that correspond to each choice of token are `a...a...`, `...b...b...`, `...c...c`, `ab...ab...`, `...bc...bc`, and `abc...abc` respectively.

Token Class **Token** is a subclass of **Linguistic Elements**. It has a lexical form, i.e., signans, and a meaning, i.e., signatum. The Plope Ontology uses placeholder classes **TokenForm** and **TokenMeaning** to represent the corresponding concepts. This thesis does not elaborate beyond the scope of **Token** and assume that for any instance of **Token**, its corresponding instances of **TokenForm** and **TokenMeaning** do not change. Therefore when two instances (of **Element**) refer to the same instance of **Token**, perfect lexical repetition is ensured since both **TokenForm** and **TokenMeaning** remain the same.

$$\begin{aligned} \text{Token} \Rightarrow \langle \{ \text{TOKEN}/(\text{self}) \}, \\ \{ \forall e_1, e_2. \text{TOKEN}(e_1, e_2) \rightarrow \text{LINGUISTICELEMENT}(e_2) \} \rangle \end{aligned}$$

$$\begin{aligned} \text{TokenForm} \Rightarrow \langle \{ \text{TOKENFORM}/(\text{self}, \text{tokenform}) \}, \\ \{ \forall e. \text{TOKEN}(e) \rightarrow \exists v. \text{TOKENFORM}(e, v), \\ \forall e, v_1, v_2. \text{TOKENFORM}(e, v_1) \wedge \text{TOKENFORM}(e, v_2) \rightarrow v_1 = v_2 \} \rangle \end{aligned}$$

$$\begin{aligned} \text{TokenMeaning} \Rightarrow \langle \{ \text{TOKENMEANING}/(\text{self}, \text{tokenmeaning}) \}, \\ \{ \forall e. \text{TOKEN}(e) \rightarrow \exists v. \text{TOKENMEANING}(e, v) \} \rangle \end{aligned}$$

refersTo

$$\begin{aligned} \text{refersTo} \Rightarrow \langle \{ \text{REFERSTO}/(\text{element}, \text{token}) \}, \\ \{ \forall e_1, e_2. \text{REFERSTO}(e_1, e_2) \rightarrow \text{ELEMENT}(e_1) \wedge \text{TOKEN}(e_2), \\ \forall e_1. \text{ELEMENT}(e_1) \rightarrow \exists e_2. \text{REFERSTO}(e_1, e_2) \wedge \text{TOKEN}(e_2) \} \rangle \end{aligned}$$

4.6 Position

4.6.1 Position Class

Position refers to the position of an occurrence of a token in a repetition. The occurrence of a token is defined as an element in Section 4.7. Instead of absolute position, ploke figures focus on respective or relative positions. A respective position is, as the name suggests, is a position with respect to another position. That is, whether a position precedes, follows, immediately precedes or immediately follows another position. For example, epizeuxis triggers an immediate repetition in which the position of an element e' immediately follows the position of an element e that e' repeats. A relative position is a position relative to a clause. That is, whether it's an initial, medial, and final-position within a clause. Ploke figures such as epanalepsis, epanaphora, mesodiplosis, epiphora, and anadiplosis are defined by tokens repeating at positions relative to a clause. For example, mesodiplosis contains tokens repeating at the middle of a clause. The Ploke Ontology does not define absolute positions with respect to a clause in this thesis.

The class **Position** has subclasses **Unpatterned Position**, **Respective Position**, and **Relative Position**. A **Relative Position** can be either **Initial**, **Medial**, or **Final**. Positions have orders

with respect to another position represented by the relation **position-order** with roles **precedes** (before) and **follows** (after). This thesis uses **precedes** and **before**, **follows** and **after** interchangeably. A **Position** can be **before** or **after** another **Position**. For example, let *p1* and *p2* be instances of the class **Position**. **before**(*p1*, *p2*) means *p1* is located before *p2*. The relation **after** is an inverse relation of **before** thus **after**(*p2*, *p1*) should be inferred given **before**(*p1*, *p2*). **Position** is linked to the class **Element** (see Section 4.7) such that each instance of **Element** has a corresponding instance of **Position**.

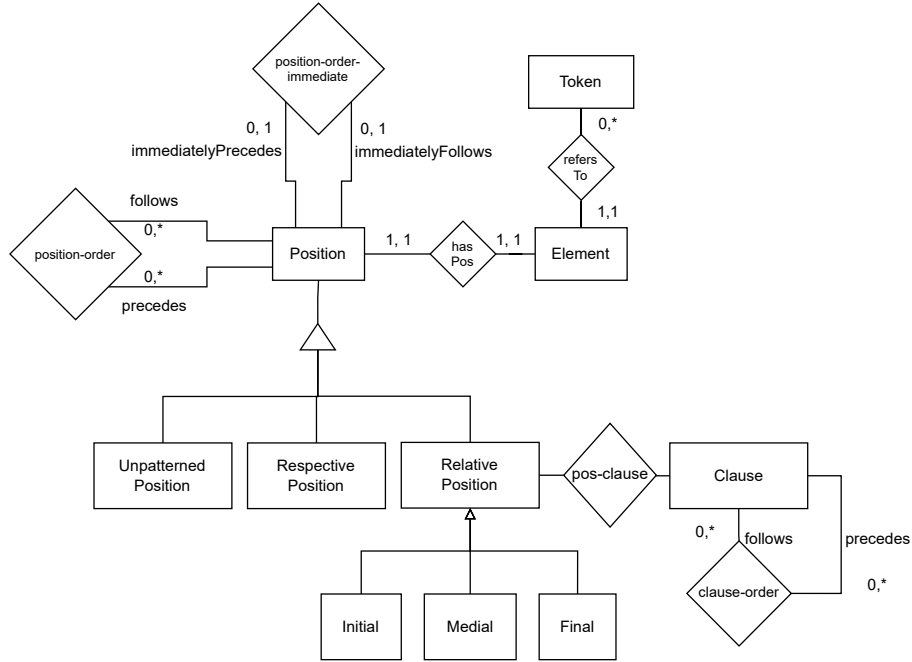


Figure 4.6: Classes and relations of **Clause** and **Position**

$$\text{Position} \Rightarrow \langle \{ \text{POSITION}/(\text{self}) \}, \{ \} \rangle$$

position-order

$$\begin{aligned} \text{position-order} \Rightarrow & \langle \{ \text{POSITION-ORDER}/(\text{precedes}, \text{follows}) \}, \\ & \{ \forall e_1, e_2. \text{POSITION-ORDER}(e_1, e_2) \rightarrow \text{POSITION}(e_1) \wedge \text{POSITION}(e_2) \} \rangle \end{aligned}$$

position-order-immediate A position immediately precedes or follows another position. Relation and roles names are simplified as follows:

position-order-immediate = pos-o-im

immediatelyPrecedes = im-precedes

immediatelyFollows = im-follows

$$\begin{aligned} \text{pos-o-im} \Rightarrow & \langle \{ \text{POS-O-IM} / (\text{im-precedes}, \text{im-follows}) \}, \\ & \{ \forall e_1, e_2. \text{POS-O-IM}(e_1, e_2) \rightarrow \text{POSITION}(e_1) \wedge \text{POSITION}(e_2), \\ & \forall e_1, e_2, e_3. \text{POS-O-IM}(e_1, e_2) \wedge \text{POS-O-IM}(e_1, e_3) \rightarrow e_2 = e_3, \\ & \forall e_1, e_2, e_3. \text{POS-O-IM}(e_2, e_1) \wedge \text{POS-O-IM}(e_3, e_1) \rightarrow e_2 = e_3 \\ & \forall e_1, e_2. \text{POS-O-IM}(e_1, e_2) \rightarrow \neg \exists e. \text{POS-O-IM}(e, e_2) \vee \text{POS-O-IM}(e_1, e) \} \rangle \end{aligned}$$

For clarity, the remainder of this thesis will use $\text{before}(e1, e2)$ or $\text{after}(e2, e1)$ to demonstrate position orders. In some cases, I use $e1 \prec e2$ for $\text{before}(e1, e2)$ and $e2 \succ e1$ for $\text{after}(e2, e1)$.

4.6.2 Unpatterned Position

$$\begin{aligned} \text{UnpatternedPos} \Rightarrow & \langle \{ \text{UNPATTERNEDPOS} / (\text{self}) \}, \\ & \{ \forall e. \text{UNPATTERNEDPOS}(e) \rightarrow \text{POSITION}(e), \\ & \forall e. \text{UNPATTERNEDPOS}(e) \rightarrow \neg \text{RESPECTIVEPOS}(e) \wedge \neg \text{RELATIVEPOS}(e) \} \rangle \end{aligned}$$

4.6.3 Respective Position

A respective position is represented by the class **RespectivePos**, which is a subclass of **Position**, and must be before or after another position.

$$\begin{aligned} \text{RespectivePos} \Rightarrow & \langle \{ \text{RESPECTIVEPOS} / (\text{self}) \}, \\ & \{ \forall e. \text{RESPECTIVEPOS}(e) \rightarrow \text{POSITION}(e), \\ & \forall e. \text{RESPECTIVEPOS}(e) \rightarrow \neg \text{UNPATTERNEDPOS}(e) \wedge \neg \text{RELATIVEPOS}(e), \\ & \forall e_1. \text{RESPECTIVEPOS}(e_1) \rightarrow \\ & \exists e_2. (\text{POSITION-ORDER}(e_1, e_2) \vee \text{POSITION-ORDER}(e_2, e_1)) \wedge \text{POSITION}(e_2) \} \rangle \end{aligned}$$

4.6.4 Relative Position

A relative position is represented by the class `RelativePos`, which is a subclass of `Position`. A relative position must be contained in a clause. See Section 4.6.5 for additional constraints.

$$\begin{aligned} \text{RelativePos} \Rightarrow \langle \{ \text{RELATIVEPOS}/(\text{self}) \}, \\ \{ \forall e. \text{RELATIVEPOS}(e) \rightarrow \text{POSITION}(e), \\ \forall e. \text{RELATIVEPOS}(e) \rightarrow \neg \text{UNPATTERNEDPOS}(e) \wedge \neg \text{RESPECTIVEPOS}(e) \} \rangle \end{aligned}$$

4.6.5 Clause

A Clause is a Linguistic Element that contains Token.

A Clause precedes or follows another Clause. A Clause can also be proximal to another Clause.

Graphically, the classes Clause and Position can be represented as in Figure 4.6.

A Clause is a Linguistic Element that contains a Token.

$$\begin{aligned} \text{Clause} \Rightarrow \langle \{ \text{CLAUSE}/(\text{self}) \}, \\ \{ \forall e. \text{CLAUSE}(e) \rightarrow \text{LINGUISTIC_ELEMENT}(e) \} \rangle \end{aligned}$$

clause-order

$$\begin{aligned} \text{clause-order} \Rightarrow \langle \{ \text{CLAUSE-ORDER}/(\text{precedes}, \text{follows}) \}, \\ \{ \forall e_1, e_2. \text{CLAUSE-ORDER}(e_1, e_2) \rightarrow \text{CLAUSE}(e_1) \wedge \text{CLAUSE}(e_2) \} \rangle \end{aligned}$$

Similar to `position-order` defined in Section 4.6.1, the remainder of this thesis will use `precedes(c1, c2)` or `follows(c2, c1)` to demonstrate clause orders. In some cases, I use $c1 \prec c2$ for `precedes(c1, c2)` and $c2 \succ c1$ for `follows(c2, c1)`.

pos-clause Since a relative position must be within a clause, the relation between a **RelativePos** and a **Clause** is defined below.

$$\begin{aligned} \text{pos-clause} \Rightarrow & \langle \{ \text{POS-CLAUSE}/(\text{relativepos}, \text{clause}) \}, \\ & \{ \forall e_1, e_2. \text{POS-CLAUSE}(e_1, e_2) \rightarrow \text{RELATIVEPOS}(e_1) \wedge \text{CLAUSE}(e_2), \\ & \forall e_1. \text{RELATIVEPOS}(e_1) \rightarrow \exists e_2. \text{POS-CLAUSE}(e_1, e_2) \} \rangle \end{aligned}$$

Initial, Medial, Final

$$\begin{aligned} \text{Initial} \Rightarrow & \langle \{ \text{INITIAL}/(\text{self}) \}, \\ & \{ \forall e. \text{INITIAL}(e) \rightarrow \text{RELATIVEPOS}(e) \} \rangle \end{aligned}$$

$$\begin{aligned} \text{Medial} \Rightarrow & \langle \{ \text{MEDIAL}/(\text{self}) \}, \\ & \{ \forall e. \text{MEDIAL}(e) \rightarrow \text{RELATIVEPOS}(e) \} \rangle \end{aligned}$$

$$\begin{aligned} \text{Final} \Rightarrow & \langle \{ \text{FINAL}/(\text{self}) \}, \\ & \{ \forall e. \text{FINAL}(e) \rightarrow \text{RELATIVEPOS}(e) \} \rangle \end{aligned}$$

4.6.6 Immediate Position

Immediate position is represented by the class **ImmediatePos** which is a subclass of **RespectivePos**. It is a position that must immediately precedes or follows another position.

Relations **immediatePrecedes** and **immediateFollows** are sub-properties of **before** and **after** respectively. Given a string **abcde**, a reasoner would infer all positions as instances of **ImmediatePos** since all characters immediately precedes or follows another character. However, only tokens involved in an immediate repetition will be affected in the scope of the Ploke Ontology. For example, given a string **aa...ba**, only the first two appearances of ‘a’ will have positions as instances of **ImmediatePos**, while the final ‘a’ should not be considered as an instance of **ImmediatePos**.

$$\begin{aligned}
\text{ImmediatePos} \Rightarrow \langle \{ & \text{IMMEDIATEPOS}/(\text{self}) \}, \\
& \{ \forall e. \text{IMMEDIATEPOS}(e) \rightarrow \text{POSITION}(e), \\
& \forall e_1. \text{IMMEDIATEPOS}(e_1) \rightarrow \\
& \exists e_2. (\text{POS-0-IM}(e_1.e_2) \vee \text{POS-0-IM}(e_2, e_1)) \wedge \text{IMMEDIATEPOS}(e_2) \} \rangle
\end{aligned}$$

4.6.7 Reversed Position

Reversed position is represented by the class **ReversedPos** which is a subclass of **RespectivePos**. It must be **before** or **after** another position, but not necessarily a position of an element in the same repetition. In practice an instance of a reversed position can be enforced with a palindrome checking algorithm. Constraints can also be constructed using path functional dependencies (PFDs) [114, 214, 222, 223] and Abstract Relational Model (ARM) [25, 26, 146]. Please see Section 5.1.

However, the reversed positions are meaningless without relating to elements that refer to the same token. They are simply instances of **RespectivePos**. There must be at least 4 position instances in the order of $e_1 \prec e_2 \prec e'_2 \prec e'_1$, and constraints must be added to restrict each of the element pairs (e_1, e'_1) and (e_2, e'_2) to refer to the same token **t1** and **t2** respectively.

$$\begin{aligned}
\text{ReversedPos} \Rightarrow \langle \{ & \text{REVERSED-POS}/(e_1, e_2, e'_2, e'_1) \}, \\
& \{ \forall e_1, e_2, e'_2, e'_1. \text{REVERSEDPOS}(e_1, e_2, e'_2, e'_1) \rightarrow \\
& \text{RESPECTIVEPOS}(e_1) \wedge \text{RESPECTIVEPOS}(e_2) \wedge \\
& \text{RESPECTIVEPOS}(e'_2) \wedge \text{RESPECTIVEPOS}(e'_1), \\
& \forall e_1, e_2, e'_2, e'_1. \text{REVERSED-POS}(e_1, e_2, e'_2, e'_1) \rightarrow \\
& \text{POSITION-ORDER}(e_1, e_2) \wedge \\
& \text{POSITION-ORDER}(e_2, e'_2) \wedge \text{POSITION-ORDER}(e'_2, e'_1) \} \rangle
\end{aligned}$$

A general version orders respective positions e_1 to e_n .

$$\begin{aligned} \text{ReversedPos} \Rightarrow \langle \{ & \text{REVERSEDPOS}(e_1, \dots e_n) \rightarrow \\ & \text{POSITION-ORDER}(e_1, e_2) \wedge \\ & \text{POSITION-ORDER}(e_2, e_3) \wedge \dots \\ & \text{POSITION-ORDER}(e_{n-1}, e_n) \} \rangle \end{aligned}$$

For example, suppose there is a passage $a \dots b \dots b \dots a$, let $ea1$, $ea2$ (correspondingly, $eb1$, $eb2$) be elements (see Section 4.7) that refer to the token ‘a’ (correspondingly for ‘b’). $pa1$, $pa2$, $pb1$ and $pb2$ are instances of *Position* that correspond to the elements $ea1$, $ea2$, $eb1$, and $eb2$ respectively. $t1$ and $t2$ are two distinct tokens.

$$\begin{aligned} & \text{Element}(ea1) \wedge \text{Element}(ea2) \\ & \wedge \text{refersTo}(ea1, t1) \wedge \text{refersTo}(ea2, t1) \\ & \wedge \text{Element}(eb1) \wedge \text{Element}(eb2) \\ & \wedge \text{refersTo}(eb1, t2) \wedge \text{refersTo}(eb2, t2) \\ & \wedge t1 \neq t2 \\ & \wedge \text{hasPos}(ea1, pa1) \wedge \text{hasPos}(ea2, pa2) \\ & \wedge \text{hasPos}(eb1, pb1) \wedge \text{hasPos}(eb2, pb2) \\ & \wedge \text{Token}(t1) \wedge \text{Token}(t2) \\ & \wedge \text{ReversedPos}(pa1) \wedge \text{ReversedPos}(pa2) \\ & \wedge \text{ReversedPos}(pb1) \wedge \text{ReversedPos}(pb2) \\ & \wedge \text{before}(pa1, pa2) \wedge \text{before}(pb1, pb2) \\ & \wedge \text{before}(pa1, pb1) \\ & \rightarrow pa1 \neq pa2 \neq pb1 \neq pb2 \\ & \wedge \text{before}(pa1, pb1) \wedge \text{before}(pb2, pa2) \end{aligned}$$

4.6.8 Position-as integer

Although not required for the Ploke Ontology, positions can be represented as integers to increase flexibility and compatibility when connecting with other rhetorical figure ontologies potentially.

$$\begin{aligned} \text{Position} \Rightarrow \langle \{ \text{POSITION}/(\text{element}, \text{pos}) \}, \\ \{ \forall e, v_1, v_2. \text{POSITION}(e_1, v_1) \wedge \text{POSITION}(e, v_2) \\ \rightarrow \text{INT}(v_1) \wedge \text{INT}(v_2) \wedge v_1 = v_2 \} \rangle \end{aligned}$$

4.7 Element

An element is defined as an occurrence of the entity that is being repeated in a repetition. It refers to a token and has a position. It can be viewed as an occurrence of a token in a repetition. For example, in a string $a \dots a$, the first occurrence of ‘a’ is an element $e1$ and the second occurrence of ‘a’ is a different element $e2$, while both are referring to the character ‘a’. This example can also be used to demonstrate the relations among the aforementioned concepts, i.e., token, position, and element. Assume the elements $e1$ and $e2$ have positions $e1_pos$ and $e2_pos$ respectively. Position $e1_pos$ is an instance of Initial, $e2_pos$ is an instance of Final. The relation before is assigned to $e1_pos$ and $e2_pos$. Both $e1$ and $e2$ refer to the token ‘a’. Then we have the following facts about $a \dots a$:

$$\begin{aligned} & \text{Element}(e1) \wedge \text{Element}(e2) \\ & \wedge \text{Initial}(e1_pos) \wedge \text{Final}(e2_pos) \\ & \wedge \text{before}(e1_pos, e2_pos) \\ & \wedge \text{refersTo}(e1, a) \wedge \text{refersTo}(e2, a) \end{aligned}$$

An element is the basic unit of a repetition. Each element is unique although it may refer to the same token within a repetition. An element may belong to multiple repetitions and are therefore part of multiple plope figures. The concept of element provides the granularity of representing each occurrence of a token and its position in a repetition. It also acts as the connection point when dealing with multiple plope figures and has the potential to extend to other rhetorical figures. For example, in a passage $a \dots b, b \dots c, c \dots a$, assuming tokens refer to characters ‘a’, ‘b’, and ‘c’, then $b, b \dots c, c \dots a$ is an instance of the figure climax assuming ‘b’, ‘c’, and ‘a’ form a semantic increase, and $a \dots a$ is an instance of the figure epanalepsis. It is possible to capture the connection between the two repetitions by analyzing the common element, i.e., the second occurrence of ‘a’, therefore connecting the two rhetorical figures.

Element Class The class **Element** relates to the class **Position** via **hasPos** and relates to **Token** via **refersTo**. Recall that a repetition has at least two elements, their positions should not be the same.

$$\begin{aligned} & \text{Element}(e1) \wedge \text{Element}(e2) \wedge \text{refersTo}(e1, t) \\ & \wedge \text{hasPos}(e1, p1) \wedge \text{hasPos}(e2, p2) \wedge \text{Token}(t) \wedge \text{Position}(p1) \wedge \text{Position}(p2) \\ & \rightarrow \text{refersTo}(e2, t) \wedge p1 \neq p2 \end{aligned}$$

Assuming $e1$ and $e2$ are elements of the same repetition, the functional dependency states that: for an element, by identify the repetition it belongs to would identify the token it refers to. It maps a relation between single repetitions and a token. It is an many-to-one relation since many repetitions can refer to the same token.

As previously described, elements are occurrences of a token in a repetition. Therefore, instances of **Element** are connected to instances of the class **Repetition** which will be discussed in the next section. Recall that an element refers to only one token and has a position.

$$\begin{aligned} \text{Element} \Rightarrow & \langle \{ \text{ELEMENT}/(\text{self}) \}, \\ & \{ \forall e1. \text{ELEMENT}(e1) \rightarrow \exists e2, e3. \text{REFERSTO}(e1, e2) \wedge \text{HASPOS}(e1, e3), \\ & \forall e1, e2, e3. \text{ELEMENT}(e1) \wedge \text{REFERSTO}(e1, e2) \wedge \text{REFERSTO}(e1, e3) \rightarrow e2 = e3 \} \rangle \end{aligned}$$

hasPos

$$\begin{aligned} \text{hasPos} \Rightarrow & \langle \{ \text{HASPOS}/(\text{element}, \text{position}) \}, \\ & \{ \forall e1, e2. \text{HASPOS}(e1, e2) \rightarrow \text{ELEMENT}(e1) \wedge \text{POSITION}(e2) \} \rangle \end{aligned}$$

4.8 Neurocognitive Affinity: Perfect Lexical Repetition

4.8.1 Overview of Perfect Lexical Repetition in Ploke

This sections gives a general overview of the neurocognitive affinity of interest, i.e., perfect lexical repetition and its subtypes. The formal EER model is presented in Section 4.8.2, Section 4.8.3, and Section 4.8.4.

Repetition is the reoccurrence of an **Element**. The **Element** in this context may be referred to as a **Token**, a phrase, or a clause. In this case the repetition is called a single repetition. **Element** can also be a repetition, e.g., forms of figures such as antimetabole and gradatio trigger nested repetitions. For now, let's treat all repetitions under the general class **Repetition**. The classification of single and nested repetition will be discussed at the end of this section. A **Repetition** consists of at least two **Elements** that refer to the same instance of a **Token**. In this case, an **Element** can be viewed as an occurrence of a **Token**. An **Element** is connected to a **Repetition** via the property `elementOf` or its inverse property `hasEle`². An **Element** has a **Position** which can be *before* or *after* another **Position**. Thus the **Elements'** **Positions** impose some order, i.e., `before(e1_pos, e2_pos)` for **Elements** *e1* and *e2*. Note that *e1_pos* and *e2_pos* are instances of the **Position** class. A **Repetition** can be defined as follows:

$$\begin{aligned} \forall rep, e1, e2. & \text{Repetition}(rep) \wedge \text{Element}(e1) \wedge \text{Element}(e2) \\ & \wedge \text{elementOf}(e1, rep) \wedge \text{elementOf}(e2, rep) \\ & \rightarrow \text{refersTo}(e1, t) \wedge \text{refersTo}(e2, t) \wedge \text{Token}(t) \\ & \wedge \text{before}(e1_pos, e2_pos) \end{aligned}$$

A **Repetition** can be an **Unpatterned Repetition**, **Relative Repetition**, **Respective Repetition**, or a **Nested Repetition**. An unpatterned repetition is triggered by the form of a **Conduplicatio**, in which repetitions are not constrained by position. Other subclasses of **Ploke** such as **Epanaphora**, **Mesodiplosis**, and **Anadiplosis** further restrict positions of their elements with respect to the clauses that contain them³. The form of each of these figures triggers **Constituent-Initial**, **Constituent-Medial**, and **Constituent-Final Repetition** respectively, all of which are subclasses of **Relative Repetition**. The form of **Epizeuxis** triggers **Immediate Repetition**, while the form of an **Antimetabole** triggers **Reversed Repetition**. Both are subclasses of **Respective Repetition**. Organization of subclasses of **Repetition** is shown in Figure 4.7.

In [Example 2.1.1](#), repetition of the word **all** can be represented by referring both **e1** and **e2** to the word **all** as in Figure 4.8. Similarly, the repetition of the word **one** can be represented using different sets of instances of **Element** referring to the word **one**. Both repetitions of **all** and **one** are triggered by forms of subclasses of **Ploke**, more specifically, an **Epanalepsis**⁴ and an **Anadiplosis**. Another repetition in [Example 2.1.1](#) is formed by the

²This thesis uses `hasEle` and `hasElement` interchangeably.

³A position can be an absolute position (e.g., position 0, 1, etc.) or a respective or relative position with respect to another element, e.g., immediately after a word, beginning of a clause, etc. For simplicity, position refers to the latter unless otherwise stated.

⁴Let's treat *A...A* as epanalepsis for now, although it refers to the repetition at the beginning and the end of the same clause.

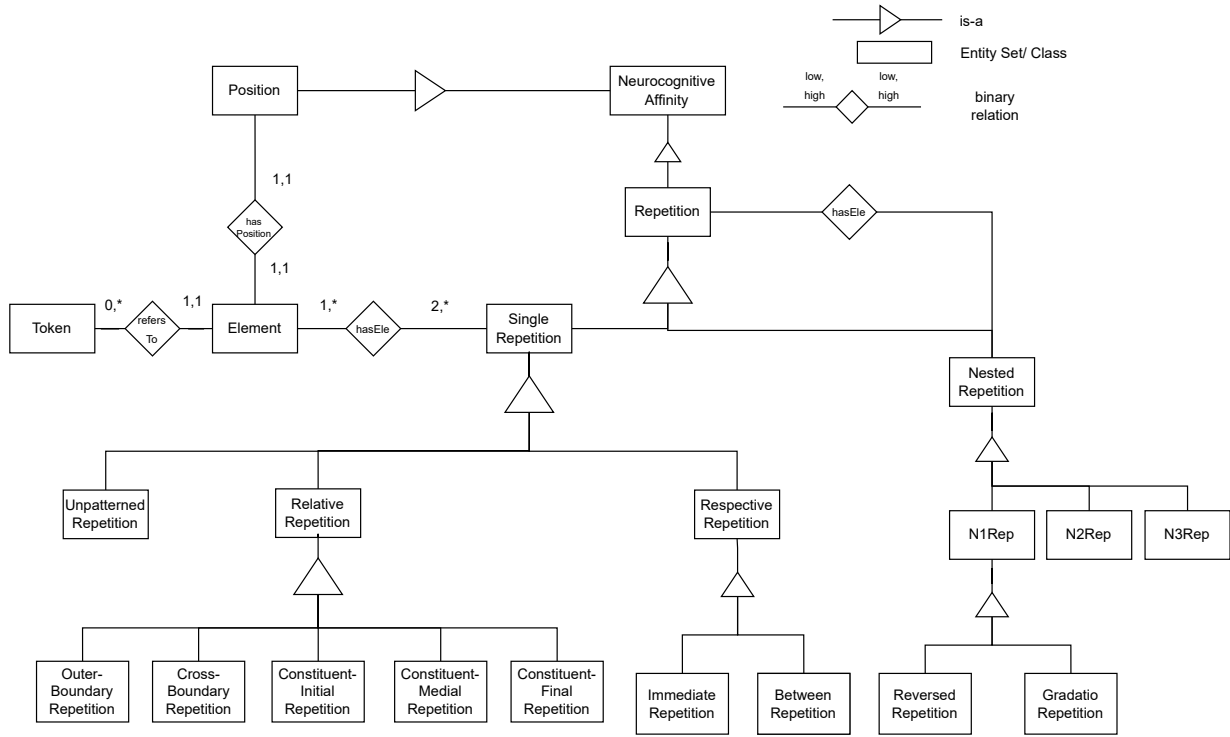


Figure 4.7: Ontological view of Repetition, a neurocognitive affinity.

word for, a Mesodiplosis. Each of these three plokcs triggers a subclass of Relative Repetition, i.e., Outer-Boundary Repetition, Cross-Boundary Repetition and Constituent-Medial Repetition. Figure 4.9 demonstrates the Cross-Boundary Repetition as an example.

The form of an Anadiplosis triggers the neurocognitive affinity of Cross-Boundary Repetition, a subclass of Relative Repetition. Let there be an arbitrary instance *c-b-rep1* of Cross-Boundary Repetition that has Elements *rep1e1* and *rep1e2*, each having its own instance of Position, i.e., *rep1e1_pos* and *rep1e2_pos*. The elements of *c-b-rep1* not only specify the order of their positions with respect to each other, but also with respect to the clauses. A Clause is a Linguistic Element that contains Token. A Clause is connected to a Relative Position which is a subclass of Position that represents a position within a clause. Other subclasses of Position are Unpatterned Position and Respective Position. A Relative Position can be either Initial, Medial, or Final. A Clause precedes or follows another Clause. A Clause can also be proximal to another Clause. Graphically, the classes Clause and Position can be represented as in Figure 4.6. The positions of elements of *c-b-rep1* must be instances of Final and Initial of the clauses in which the anadiplosis is contained

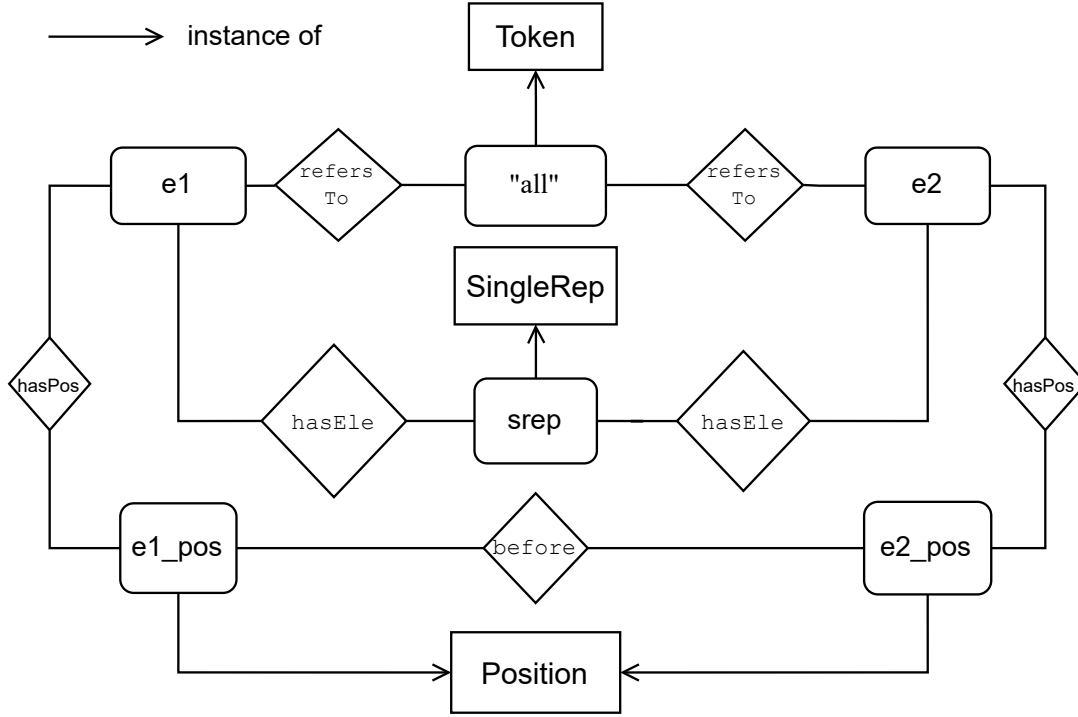


Figure 4.8: Example of a Repetition using [Example 2.1.1](#). More specifically, this is an example of a **SingleRep** which will be discussed later in this section.

in. For example, let $c1$ and $c2$ be instances of **Clause** and $\text{precedes}(c1, c2)$. The positions of elements rep1e1 and rep1e2 are located in $c1$ and $c2$ respectively. Now let's replace all parameters above with values of [Example 2.1.1](#), the string values of $c1$ and $c2$ are **all for one** and **one for all** respectively. Both rep1e1 and rep1e2 refer to the token **one**. In this case, the position of rep1e1 must be an end position of $c1$. Thus rep1e1_pos is an instance of **Final** that is linked to $c1$. Similarly, rep1e2_pos is an instance of **Initial** that is linked to $c2$. Another relation between the clauses is the $\text{proximal}(c1, c2)$ to indicate proximity between the clauses. Similarly, a **Constituent-Initial**, **Constituent-Medial**, and **Constituent-Final** Repetition triggered by Epanaphora, Mesodiplosis, and Epiphora respectively, has both elements with positions that are instances of **Initial**, **Medial**, and **Final** respectively. In the case of Epanalepsis, positions of elements are the opposite of that in the case of Anadiplosis, i.e., rep1e1_pos and rep1e2_pos are instances of **Initial** and **Final**

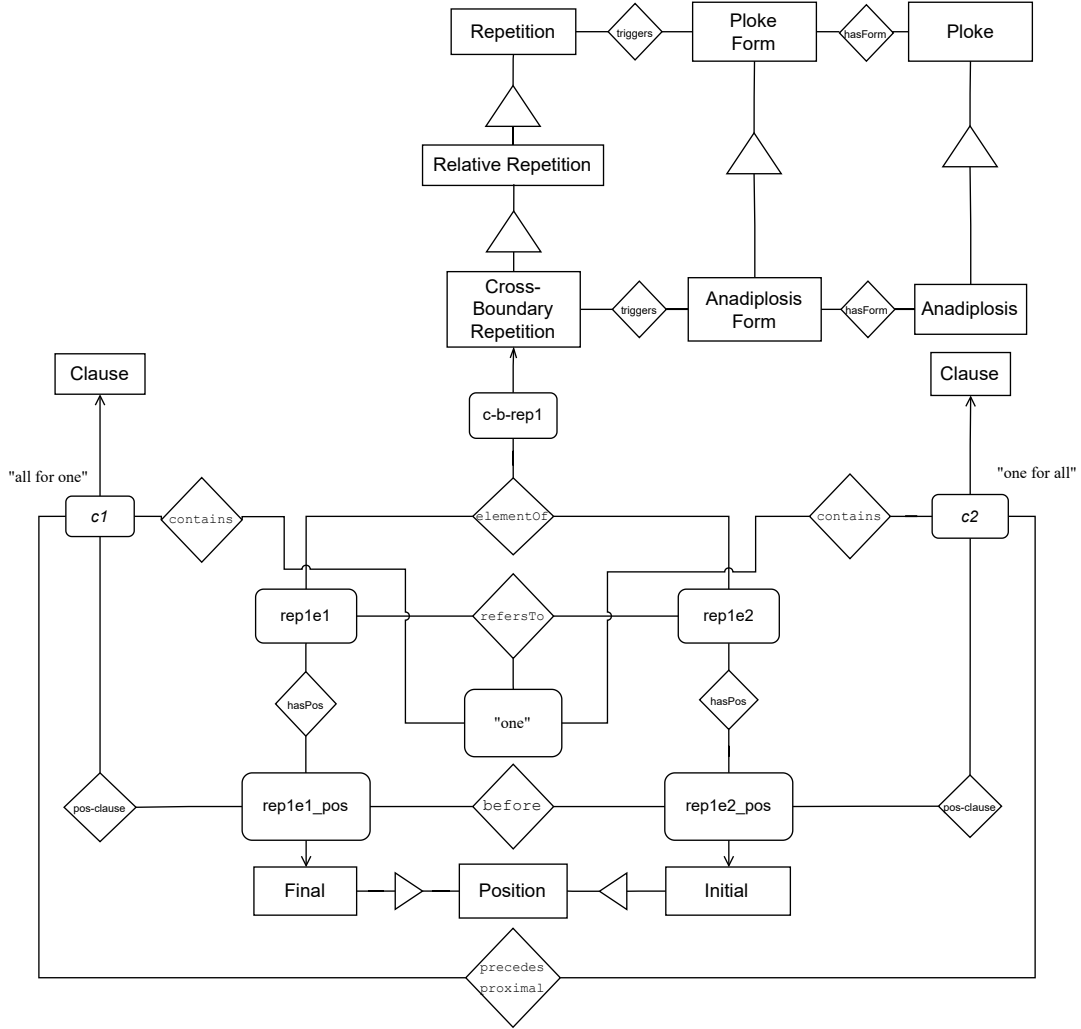


Figure 4.9: Example of Cross-Boundary Repetition using [Example 2.1.1](#)

respectively.

The form of an antimetabole triggers a Reversed Repetition, which is a subclass of Repetition. The elements of Reversed Repetition are Repetitions. Let *rep1* and *rep2* be instances of Repetition and *rep1e1*, *rep1e2*, *rep2e1* and *rep2e2* be elements of *rep1* and *rep2* defined as the instance *srep* in Figure 4.8 accordingly, then an instance *revRep1* of Reversed

Repetition can be defined as follows and graphically in Figure 4.10:

$$\begin{aligned} & \text{ReversedRep}(\text{revRep1}) \wedge \text{elementOf}(\text{rep1}, \text{revRep1}) \\ & \quad \wedge \text{elementOf}(\text{rep2}, \text{revRep1}) \\ & \rightarrow \text{before}(\text{rep1e1_pos}, \text{rep2e1_pos}) \\ & \quad \wedge \text{before}(\text{rep2e1_pos}, \text{rep2e2_pos}) \\ & \quad \wedge \text{before}(\text{rep2e2_pos}, \text{rep1e2_pos}) \end{aligned}$$

Replacing all parameters with values in [Example 2.1.1](#), `rep1e1`, `rep1e2` both refer to the word `all` and `rep2e1`, `rep2e2` both refer to the word `one`. The order of positions of

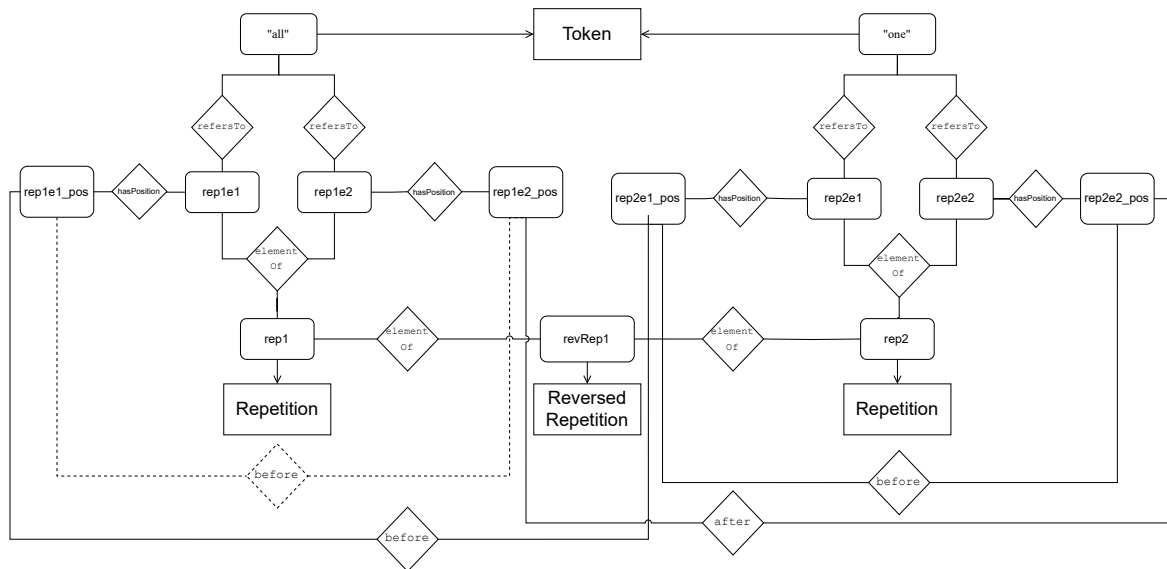


Figure 4.10: Example of Reversed Repetition using [Example 2.1.1](#)

the elements is, in conventional notation, `rep1e1_pos` $\prec$ `rep2e1_pos` $\prec$ `rep2e2_pos` $\prec$ `rep1e2_pos`. Note that in this case the positions are not instances of **Relative Position**, but of **Respective Position** with relations **before** and **after** representing the order of the position of each element with respect to each other. Since relations **before** and **after** are transitive, the relation **before**(`rep1e1_pos`, `rep1e2_pos`) defined as part of the definition (i.e., the dashed line in Figure 4.10) of **rep1** is implicit from the definition of **revRep1**.

Recall that neurocognitive affinities such as symmetry, balance and opposition are the results of multiple repetitions occurring at specific positions. They are the compound neurocognitive affinities and repetition and position are the primary neurocognitive affinities

triggered by the form of a plope. In the scope of **Plope**, they are certainly contributed by the subclasses of **Repetition**. A **Clause-Medial Repetition** contributes to balance, a **Clause-Boundary Repetition** contributes to opposition, a **Reversed Repetition** together with a **Clause-Medial Repetition** contribute to both balance and opposition, etc. In the case of [Example 2.1.1](#), the combination of antimetabole and mesodiplosis produces a stronger balance. Thus, the Plope Ontology does not attempt to represent the compound neurocognitive affinities such as balance and opposition which can be represented with the combinations of **Repetition** and **Position** and their subclasses.

Note that the definition of nested repetition contains a cycle. In order to represent repetitions computationally, the Plope Ontology redefines **Repetition** and classifies it into **Single Repetition** and **Nested Repetition** and restricts the level of abstraction of instances of **Nested Repetition**. A **Single Repetition** is a subclass of **Repetition** that is connected to the class **Element** that refer to a word or word group and has a position. A **Nested Repetition** is a subclass of **Repetition** in which the elements are instances of subclasses of **Nested Repetition** or **Single Repetition**. For simplicity, this thesis uses **SingleRep** and **NestedRep** to refer to the classes **Single Repetition** and **Nested Repetition** respectively.

Single Repetition A single repetition has at least two elements. Suppose a tree with only **hasEle** as its edges, then single repetitions will always link to elements, which are the leaves of the tree. There are three subtypes of single repetition: unpatterned repetition, respective repetition, and relative repetition. An unpatterned repetition does not have any restriction on the position of its elements.

The forms of plope figures such as epanalepsis, epanaphora, mesodiplosis, epiphora, and anadiplosis trigger relative repetitions. These are the repetitions in which elements have positions that are relative positions which can be at an initial, medial, or end position with respective to a clause. Relative repetition can have subtypes of outer-boundary repetition, clause-initial repetition, clause-medial repetition, clause-end repetition, or cross-boundary repetition which are triggered by the forms of the aforementioned plokcs respectively.

A respective repetition has elements in which the positions are respective. That is, the elements of a respective repetition must have additional constraints on the **before** or **after** relations with respect to another element in the same repetition. An example is the immediate repetition triggered by the form of an epizeuxis, i.e., ...**aa**... The elements ‘**a**’ must be next to each other to form an immediate repetition. Antimetabole is a special case. Intuitively it should be a subtype of respective repetition but it’s defined as a nested repetition in the Plope Ontology.

Nested Repetition Another subtype of repetition is a nested repetition, in which its elements are themselves repetition. In other words, a nested repetition is the repetition of repetitions.

A nested repetition has at least two repetitions as its elements. This means that a nested repetition may create a loop of nested repetitions but will eventually reach a single repetition which in turn has at least two elements. A nested repetition cannot be connected to an element directly. It must connect to a single repetition before reach an element.

The goal of nested repetition is to represent the repetition triggered by subtypes of plope such as antimetabole and gradatio. For example, in [Example 2.1.1](#), the antimetabole form by `all...one`, `one...all` can be viewed as a nested repetition of two single repetitions, `all...all` and `...one`, `one...`. Such a nested repetition in which all of its elements are single repetitions is a level 1 nested repetition, denoted N^1Rep . A nested repetition in which at least one of its elements is a nested repetition is a level 2 nested repetition, denoted N^2Rep .

It is possible to have N^nRep where n is infinite (or finitely large). However, it is out of the scope of this thesis to express the universal set of all nested repetitions. The repetitions triggered by plope forms are in a subset of all nested repetitions in which n can be relatively small. For example, both antimetabole and gradatio trigger level 1 nested repetition N^1Rep . In practice, this conceptual model of the Plope Ontology applies to passages in text documents in which it is unlikely to have an infinite (or finitely large) loop. We introduce a limit k on the level of nested repetition n . In this thesis I assume $k = 3$ to increase the range of lexical repetitions this ontology can represent, such as abstractions of higher level nested repetition created by complex plokess such as antimetabole and gradatio and the combination of other figures. Having a higher k also increases the flexibility of representation such that repetition can be represented in different ways as shown in [Section 4.9](#). The conceptual model also provides flexibility in case new plope figures are invented in the future and leaves room for potential extension to connect with other rhetorical figure ontologies especially potential ontologies on other types of figures of repetition such as rhyme (repetition of ending syllables), parison (repetition of syntactical structures), etc. The Plope Ontology uses classes **N3Rep**, **N2Rep**, and **N1Rep** to represent the concepts N^3Rep , N^2Rep , and N^1Rep respectively. k also serves as an indicator of how many nested repetitions are required to reach a single repetition. In other words, a single repetition is a nested repetition where $k = 0$.

The same instance of Plope may have different representation using single or nested repetition. For example, the quote `all for one`, `one for all` can be represented using the following ways:

1. Using three single repetitions: `all...all`, `...for...`, `...for...` and `...one, one....`. Each single repetition is triggered by the form of Epanalepsis, Mesodiplosis, and Anadiplosis respectively, all of which are subclasses of Ploke.
2. A nested repetition `all...one`, `one...all`, and a single repetition `...for...`, `...for....`. They are triggered by the form of Antimetabole and Mesodiplosis respectively.
3. A nested repetition with three elements, each element is a single repetition in 1. This nested repetition does not relate to any ploke in this ontology. However, the representation provides the flexibility to connect a potential new ploke to this nested repetition.

The reversed repetition triggered by the form of an antimetabole is a special case since it is both a respective repetition but also a nested repetition. In this ontology, the reversed repetition is represented as a nested repetition with single repetitions as its elements. For example, `a...a` and `...b...b...` are two separate respective repetitions which are in turn two separate single repetitions. The repetitions are characterized by the positions of elements ‘a’ or ‘b’ in `a...a` or `...b...b...` respectively. However, treating them as two independent single repetitions does not capture the characteristics of a reversed repetition. The reversed repetition occurs when the two single repetitions are *nested* together to become `a...b...b...a`. Thus the class **Reversed Repetition** will be categorized as a subclass of **N1Rep** which in turn a subclass of **NestedRep** and **Respective Repetition** as a subclass of **SingleRep**. This thesis demonstrates two subtypes of N^1Rep which are directly related to Ploke, **Reversed Repetition**, triggered by the form of an antimetabole, and **Gradatio Repetition** triggered by a gradatio, both are subtypes of N^1Rep . This section already demonstrated an example for reversed repetition, and gradatio repetition is demonstrated below.

A gradatio is a sequence of anadiplosis. Consider [Example 3.4.10](#):

One voice can change a room. And if it can change a room,
it can change a city. And if it can change a city,
it can change a state. And if it can change a state,
it can change a nation. And if it can change a nation,
it can change a world. [176]

The so called Gradatio Repetition (**GradatioRep**) is triggered by the form of a gradatio, which consists of multiple anadiplosis, i.e., `...change a room ...change a room ...`,

...change a city ...change a city ..., ...change a state ...change a state ..., and ...change a nation ...change a nation Figure 4.11 represents a simplified version of of the [Example 3.4.10](#).

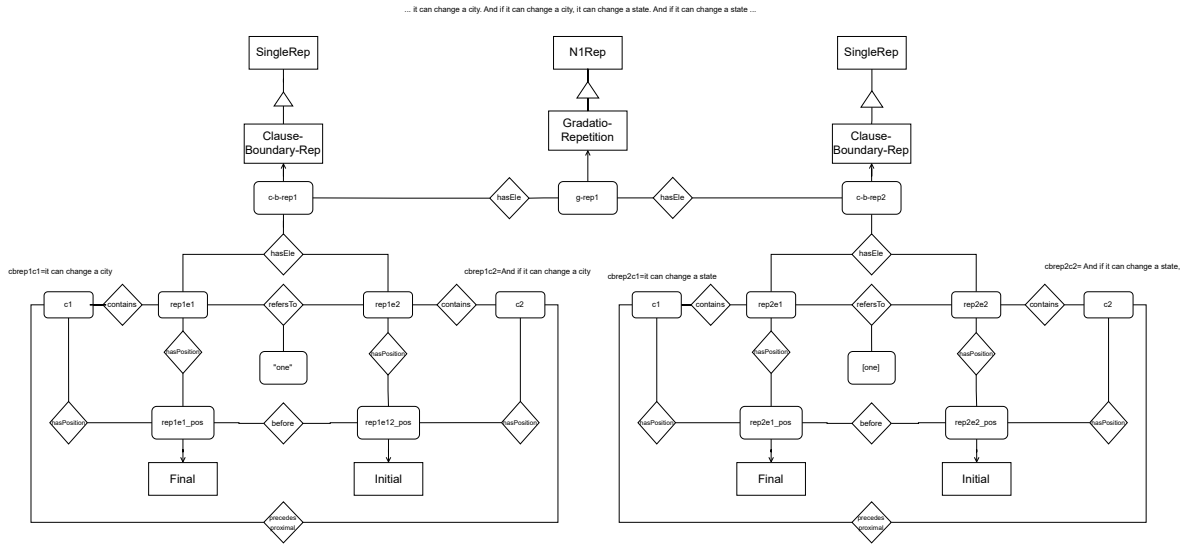


Figure 4.11: Example of Gradatio Repetition using [Example 3.4.10](#)

A single repetition is similar to the traditional sense of a repetition. In this ontology it is a foundation of nested repetition instead of a comprehensive concept for repetition. It is at the single repetition level that the elements must refer to the same token. A nested repetition such as a reversed repetition or a gradatio repetition can refer to multiple tokens at its leaves since it eventually connects to multiple single repetitions as in [Example 2.1.1](#).

4.8.2 Repetition

This section provides the formal EER model for **Repetition** and its subclasses.

A **Repetition** is

- a subclass of **Neurocognitive Affinity**,
- can be either **SingleRep** or **NestedRep**,
- has at least 2 **hasEle** relations whose values are instances of **Repetition** or **Element**,

- eventually all paths of **hasEle** will reach a **SingleRep** and in turn the class **Element**,
- Tokens of a **SingleRep** should be the same, and
- note that a **NestedRep** may involve multiple Tokens, e.g., a b b a in a **Reversed Repetition**.

$$\begin{aligned} \text{Repetition} \Rightarrow \{ \{ \text{REPETITION} / (\text{self}) \}, \\ \{ \forall e. \text{REPETITION}(e) \rightarrow \text{NEUROCOGNITIVE AFFINITY}(e), \\ \forall e. \text{REPETITION}(e) \rightarrow \text{SINGLEREP} \vee \text{NESTEDREP}(e) \} \} \end{aligned}$$

hasEle

$$\begin{aligned} \text{hasEle} \Rightarrow \{ \{ \text{HASELE} / (\text{repetition}, \text{element} \vee \text{repetition}) \}, \\ \{ \forall e_1. \text{REPETITION}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE}(e_1, e_2) \wedge \text{HASELE}(e_1, e_3) \wedge e_2 \neq e_3, \\ \forall e_1, e_2. \text{HASELE}(e_1, e_2) \rightarrow \text{REPETITION}(e_1) \wedge (\text{ELEMENT}(e_2) \vee \text{REPETITION}(e_2)) \} \} \end{aligned}$$

This is a definition for general **hasEle** relation. Sub-properties of **hasEle** can be defined for more specific relations between subclasses of **Repetition**, e.g., as shown in the following triples and discussed in later sections, (**SingleRep**, **hasEle-s**, **Element**), (**N3Rep**, **hasEle-n3**, (**N2Rep** $\vee$ **SingleRep**)), (**N2Rep**, **hasEle-n2**, (**n2rep** $\vee$ **single rep**)), and (**N1Rep**, **hasEle-n1**, **singleRep**).

4.8.3 Single Repetition

SingleRep

A **SingleRep**

- is a subclass of **Repetition**
- is disjoint with **NestedRep**
- has at least 2 **hasEle** in which the values are instances of **Element**

- Elements of the same instance of SingleRep refer to (refersTo the same instance of Token.

$$\begin{aligned} \text{SingleRep} \Rightarrow \langle \{ & \text{SINGLEREP}/(\text{self}) \}, \\ & \{ \forall e. \text{SINGLEREP}(e) \rightarrow \text{REPETITION}(e), \\ & \forall e. \text{SINGLEREP}(e) \rightarrow \neg \text{NESTEDREP}(e) \} \rangle \end{aligned}$$

hasEle-s

$$\begin{aligned} \text{hasEle-s} \Rightarrow \langle \{ & \text{HASELE-S}/(\text{singlerep}, \text{element}) \}, \\ & \{ \forall e_1. \text{SINGLEREP}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE-S}(e_1, e_2) \wedge \text{HASELE-S}(e_1, e_3) \wedge e_2 \neq e_3, \\ & \forall e_1, e_2. \text{HASELE-S}(e_1, e_2) \rightarrow \text{SINGLEREP}(e_1) \wedge (\text{ELEMENT}(e_2)), \\ & \forall e_1, e_2, e_3, t_1, t_2. \text{SINGLEREP}(e_1) \wedge \text{HASELE-S}(e_1, e_2) \wedge \text{HASELE-S}(e_1, e_3) \\ & \wedge \text{REFERSTO}(e_2, t_1) \wedge \text{REFERSTO}(e_3, t_2) \rightarrow t_1 = t_2 \} \rangle \end{aligned}$$

Unpatterned Rep

$$\begin{aligned} \text{UnpatternedRep} \Rightarrow \langle \{ & \text{UNPATTERNEDREP}/(\text{self}) \}, \\ & \{ \forall e. \text{UNPATTERNEDREP}(e) \rightarrow \text{SINGLEREP}(e), \\ & \forall e_1, e_2, e_3. \text{UNPATTERNEDREP}(e_1) \wedge \text{HASELE-S}(e_1, e_2) \\ & \wedge \text{HASPOS}(e_2, e_3) \rightarrow \neg \text{UNPATTERNEDPOS}(e_3) \} \rangle \end{aligned}$$

Respective Rep

RespectiveRep has elements with positions that are with respect to other elements.

$$\begin{aligned} \text{RespectiveRep} \Rightarrow \langle \{ & \text{RESPECTIVEREP}/(\text{self}) \}, \\ & \{ \forall e. \text{RESPECTIVEREP}(e) \rightarrow \text{SINGLEREP}(e), \\ & \forall e_1, e_2, e_3. \text{RESPECTIVEREP}(e_1) \wedge \text{HASELE-S}(e_1, e_2) \\ & \wedge \text{HASPOS}(e_2, e_3) \rightarrow \neg \text{RESPECTIVEPOS}(e_3) \} \rangle \end{aligned}$$

Relative Rep

RelativeRep has elements with positions that are with respect to clauses.

$$\begin{aligned} \text{RelativeRep} \Rightarrow & \langle \{ \text{RELATIVEREP}/(\text{self}) \}, \\ & \{ \forall e. \text{RELATIVEREP}(e) \rightarrow \text{SINGLEREP}(e), \\ & \forall e_1, e_2, e_3. \text{RELATIVEREP}(e_1) \wedge \text{HASELE-S}(e_1, e_2) \\ & \wedge \text{HASPOS}(e_2, e_3) \rightarrow \neg \text{RELATIVEPOS}(e_3) \} \rangle \end{aligned}$$

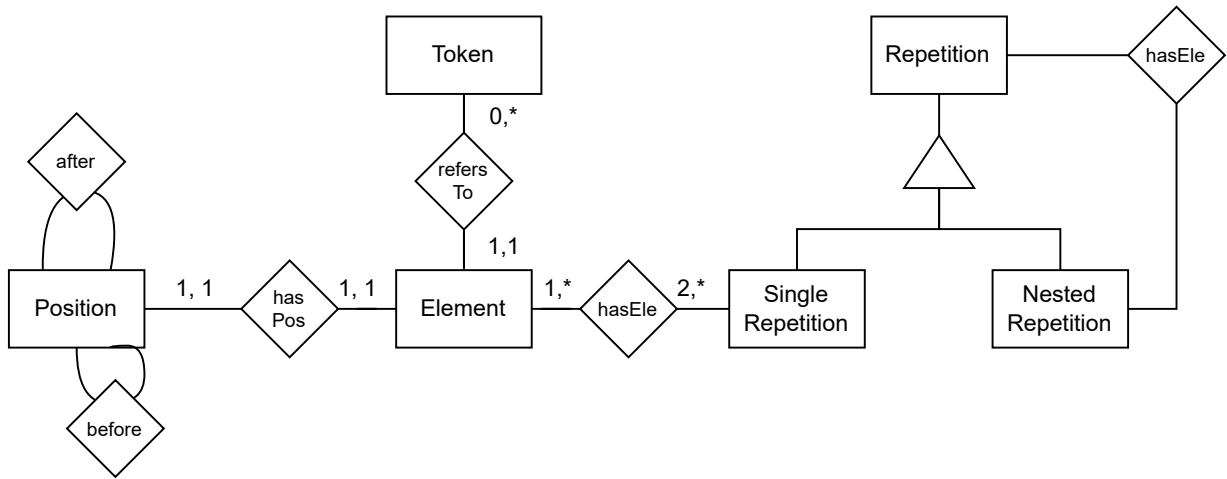


Figure 4.12: SingleRep and NestedRep

4.8.4 Nested Repetition

NestedRep

A NestedRep

- is a subclass of **Repetition**
- is disjoint with **SingleRep**
- has at least 2 **hasEle** in which the values are instances of **Repetition**

- eventually reaches **SingleRep**

Elements of a nested repetition must be a nested or single repetition Eventually reaches **SingleRep**: cannot be expressed in FOL but can be expressed using the subclasses of **NestedRep**: **N3Rep**, **N2Rep**, and **N1Rep**.

$$\begin{aligned} \text{NestedRep} \Rightarrow & \langle \{ \text{NESTEDREP} / (\text{self}) \}, \\ & \{ \forall e. \text{NESTEDREP}(e) \rightarrow \text{REPETITION}(e), \\ & \forall e. \text{NESTEDREP}(e) \rightarrow \neg \text{SINGLEREP}(e), \\ & \forall e. \text{NESTEDREP}(e) \rightarrow \text{N3REP}(e) \vee \text{N2REP}(e) \vee \text{N1REP}(e) \} \rangle \end{aligned}$$

NestedRep is the generalized notion of a tree with m nodes and n edges (**hasEle**) at each level that expands finitely until h levels with nodes $m_{h,i}$. At $h + 1$ level each node is an **Element** which the elements e_i from (**hasEle**) each node $m_{h,i}$ points to the same token, t_i , where $i = 1 \dots n$, and the language L for the set of passage generated by a **NestedRep** is $\{t_1^+, t_2^+, \dots, t_n^+\}^*$. Each t_i appears k times where $2 \leq k \leq n$. This is essentially every possible perfect lexical repetition.

Let n^0ri be a node of **SingleRep**. That is, a nested repetition at level 0. Then level 1 of **NestedRep** is called n^1ri where $0 \leq i \leq n$. Each n^1ri is an individual repetition that is connected to at least two n^0ri (instances of **SingleRep**) nodes via **hasEle**. n^2ri connects to at least one n^1ri nodes. It can connect to one n^1ri node and one n^0ri (**SingleRep**), but it cannot connect to a higher level nested repetition. n^3ri connects to at least one n^2ri , and so on. Generally, we have n^jri where $0 \leq i \leq n$, $0 \leq j \leq m$, in which n^jri connects to at least one $n^{j-1}ri$ node.

Looking from another perspective, any instance of **NestedRep** focuses on a subtree in which a root node n^jri is selected arbitrarily. That is, one may view the construction of the tree as bottom-up from the leaves (i.e., tokens) instead of constructed from a root, where a branch **hasEle** of the parent of the selected root n^jri is finitely large. Every n^jri is connected to at least two $n^{j'}ri$ nodes, one of which is a $n^{j-1}ri$ node via **hasEle**, which eventually connects to a n^0ri (**SingleRep**) node. Thus there is no infinite branch via the edge **hasEle** in the scope of **NestedRep** in the Ploke Ontology.

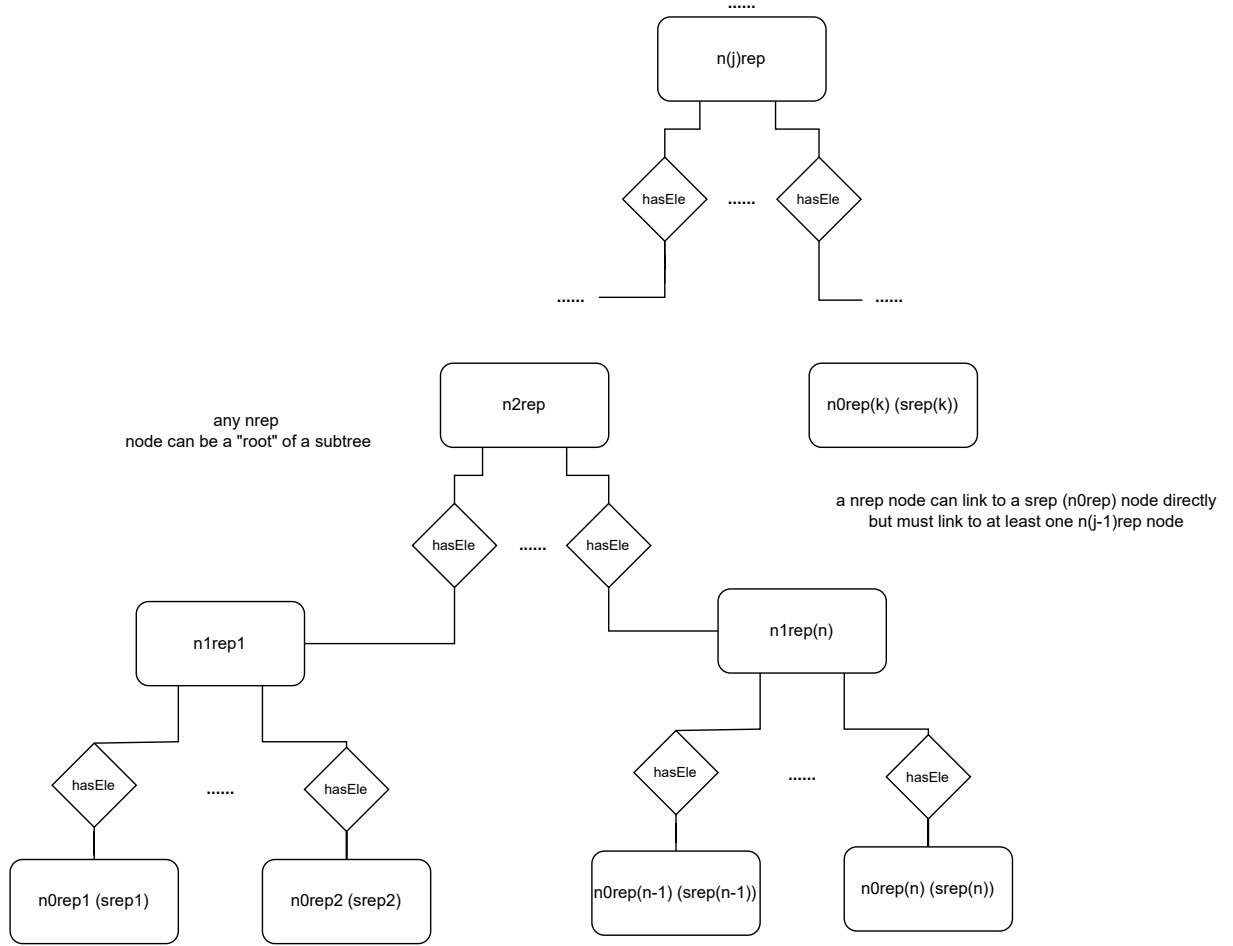


Figure 4.13: Tree diagram for NestedRep

hasEle-n

$$\begin{aligned}
 \text{hasEle-n} \Rightarrow & \langle \{ \text{HASELE-N} / (\text{nestedrep}, \text{repetition}) \}, \\
 & \{ \forall e_1. \text{NESTEDREP}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE-N}(e_1, e_2) \wedge \text{HASELE-N}(e_1, e_3) \wedge e_2 \neq e_3, \\
 & \forall e_1, e_2. \text{HASELE-N}(e_1, e_2) \rightarrow \text{NESTEDREP}(e_1) \wedge (\text{REPETITION}(e_2)) \} \rangle
 \end{aligned}$$

In general, a nested repetition can have k levels as discussed in Section 4.8.1. This thesis restricts k to 3 to demonstrate the Ploke Ontology. Let $k = 3$, then **NestedRep** has subclasses **N3Rep**, **N2Rep** and **N1Rep**.

A N3Rep

- is a subclass of NestedRep
- is disjoint with N2Rep, N1Rep
- has at least 2 hasEle in which the values are instances of N2Rep or N1Rep or SingleRep
- has at least one hasEle that connects to an instance of N2Rep

Its element must be N2Rep, N1Rep, or SingleRep:

$$\begin{aligned} \text{N3Rep} \Rightarrow \langle \{ \text{N3REP}/(\text{self}) \}, \\ \{ \forall e. \text{N3REP}(e) \rightarrow \text{NESTEDREP}(e), \\ \forall e. \text{N3REP}(e) \rightarrow \neg(\text{N2REP}(e) \vee \text{N1REP}(e)) \} \rangle \end{aligned}$$

hasEle-n3

$$\begin{aligned} \text{hasEle-n3} \Rightarrow \langle \{ \text{HASELE-N3}/(\text{n3rep}, \text{n2rep} \vee \text{n1rep} \vee \text{single rep}) \}, \\ \{ \forall e_1. \text{N3REP}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE-N3}(e_1, e_2) \wedge \text{HASELE-N3}(e_1, e_3) \wedge e_2 \neq e_3, \\ \forall e_1, e_2. \text{HASELE-N3}(e_1, e_2) \rightarrow \text{N3REP}(e_1) \wedge (\text{N2REP}(e_2) \vee \text{N1REP}(e_2) \vee \text{SINGLEREP}(e_2)), \\ \forall e_1. \text{N3REP}(e_1) \rightarrow \exists e_2. \text{N2REP} \wedge \text{HASELE-N3}(e_1, e_2) \} \rangle \end{aligned}$$

A N2Rep

- is a subclass of NestedRep
- is disjoint with N3Rep, N1Rep
- has at least 2 hasEle in which the values are instances of N1Rep or SingleRep
- has at least one hasEle that connects to an instance of N1Rep

$$\begin{aligned} \text{N2Rep} \Rightarrow \langle \{ \text{N2REP}/(\text{self}) \}, \\ \{ \forall e. \text{N2REP}(e) \rightarrow \text{NESTEDREP}(e), \\ \forall e. \text{N2REP}(e) \rightarrow \neg(\text{N3REP}(e) \vee \text{N1REP}(e)) \} \rangle \end{aligned}$$

hasEle-n2

$$\begin{aligned} \text{hasEle-n2} \Rightarrow \langle \{ & \text{HASELE-N2}/(\text{n2rep}, \text{n1rep} \vee \text{single rep}) \}, \\ & \{ \forall e_1. \text{N2REP}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE-N2}(e_1, e_2) \wedge \text{HASELE-N2}(e_1, e_3) \wedge e_2 \neq e_3, \\ & \forall e_1, e_2. \text{HASELE-N2}(e_1, e_2) \rightarrow \text{N2REP}(e_1) \wedge (\text{N1REP}(e_2) \vee \text{SINGLEREP}(e_2)), \\ & \forall e_1. \text{N2REP}(e_1) \rightarrow \exists e_2. \text{N1REP} \wedge \text{HASELE-N2}(e_1, e_2) \} \rangle \end{aligned}$$

A N1Rep

- is a subclass of NestedRep
- is disjoint with N3Rep, N2Rep
- has at least 2 hasEle in which the values are instances of SingleRep

$$\begin{aligned} \text{N1Rep} \Rightarrow \langle \{ & \text{N1REP}/(\text{self}) \}, \\ & \{ \forall e. \text{N1REP}(e) \rightarrow \text{NESTEDREP}(e), \\ & \forall e. \text{N1REP}(e) \rightarrow \neg(\text{N3REP}(e) \vee \text{N2REP}(e)) \} \rangle \end{aligned}$$

hasEle-n1

$$\begin{aligned} \text{hasEle-n1} \Rightarrow \langle \{ & \text{HASELE-N1}/(\text{n1rep}, \text{single rep}) \}, \\ & \{ \forall e_1. \text{N1REP}(e_1) \rightarrow \exists e_2, e_3. \text{HASELE-N1}(e_1, e_2) \wedge \text{HASELE-N1}(e_1, e_3) \wedge e_2 \neq e_3, \\ & \forall e_1, e_2. \text{HASELE-N1}(e_1, e_2) \rightarrow \text{N1REP}(e_1) \wedge \text{SINGLEREP}(e_2) \} \rangle \end{aligned}$$

A quick summary about NestedRep:

- It has at least 2 Elements via hasEle, with some upper bound m .
- Elements can be both SingleRep or NestedRep.
- can have different types of elements, i.e., m SingleRep and n NestedRep, at the same level.
- Every hasEle is guaranteed to reach an instance of SingleRep from an arbitrary NestedRep node which can be seen as the root.

- **NestedRep** nodes can grow to infinity with hasEle^- . This thesis restricts the level of abstraction to $k = 3$.
- **SingleRep** is a more basic unit of **NestedRep**, i.e., $N^0\text{Rep}$. **NestedRep** eventually connects to **SingleRep**.
- An instance of **Repetition** may have different representations using multiple (possibly 0 for **SingleRep**) levels of **NestedRep**.

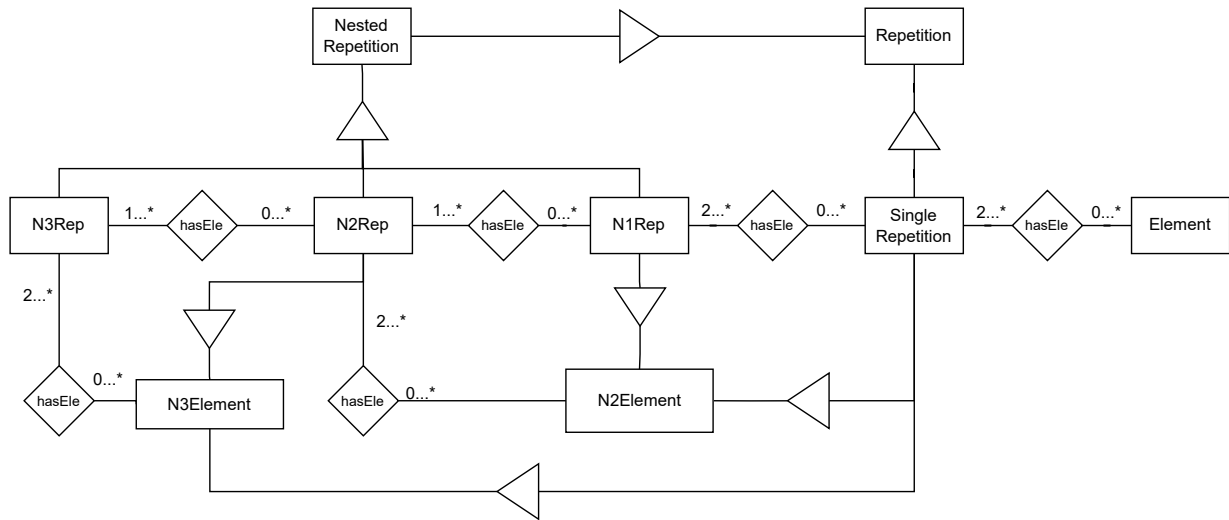


Figure 4.14: Subclasses of **NestedRep**

Reversed Rep

A ReversedRep

- is a subclass of **N1Rep**
- has at least 2 **hasEle** in which the values are instances of **SingleRep**
- the elements of **SingleReps** (leaves) are in a reversed order, e.g., $a1_pos \prec b1_pos \prec b2_pos \prec a2_pos$ for $a \dots b \dots b \dots a$ where $a1$, $a2$ are elements of a , similar for $b1$ and $b2$.

$$\begin{aligned}
\text{ReversedRep} \Rightarrow & \langle \{ \text{REVERSEDREP} / (\text{self}) \}, \\
& \{ \forall e. \text{REVERSEDREP}(e) \rightarrow \text{N1REP}(e), \\
& \forall e_1, e_2, e_3. \text{REVERSEDREP}(e_1) \wedge \text{HASELE-N1}(e_1, e_2) \\
& \wedge \text{HASELE-N1}(e_1, e_3) \\
& \rightarrow \exists e_2p, e_3p, e_3p', e_2p'. (\text{HASELE-S}(e_2, -) \wedge \text{HASPOS}(-, e_2p)) \\
& \wedge (\text{HASELE-S}(e_2, -) \wedge \text{HASPOS}(-, e_2p')) \\
& \wedge (\text{HASELE-S}(e_3, -) \wedge \text{HASPOS}(-, e_3p)) \\
& \wedge (\text{HASELE-S}(e_3, -) \wedge \text{HASPOS}(-, e_3p')) \\
& \wedge \text{REVERSED-POS}(e_2p, e_3p, e_3p', e_2p') \} \rangle
\end{aligned}$$

The elements in single repetitions e_2 and e_3 each refers to an identical token by definition of **SingleRep**. The ‘ $-$ ’ represents an anonymous variable.

For example, assuming an instance *nrep1* points to *srep1* and *srep2*, each has two elements *srep1e1*, *srep1e2*, *srep2e1*, and *srep2e2* respectively, with positions in the order: *srep1e1_pos* $\prec$ *srep2e1_pos* $\prec$ *srep2e2_pos* $\prec$ *srep1e2_pos*

This dependency states that: for two elements in the same single repetition, the element before e_1 and after e_2 must also be from another single repetition. Note that for an antimetabole it is always in the form of *abba*. A case such as *abbba* and *abc...cba* can both be parsed into *abba*. The second case is a nested repetition with three single repetitions but the functional dependency can be applied from inside-out, e.g., *bccb* first then to *abba*, then obtain the final ordering by transitivity.

Given that the users’ instantiations of the orders of the positions are correct, a reversed repetition can be represented using **before** and **after** relations in elements of both repetitions. A full order specification would be ideal but it can also be partially specified. For example, suppose there are single repetitions **rep1** and **rep2** with elements and their positions defined as in Figure 4.10. Suppose we have only the following information of positions of elements within each single repetition.

Given: **before**(*rep1e1_pos*, *rep1e2_pos*), **before**(*rep2e1_pos*, *rep2e2_pos*), i.e., *rep1e1_pos* $\prec$ *rep1e2_pos* and *rep2e1_pos* $\prec$ *rep2e2_pos*

Since these are elements of a reversed repetition, it must be one of the following two cases:

Case 1: $\text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep2e2_pos} \prec \text{rep1e2_pos}$

Case 2: $\text{rep2e1_pos} \prec \text{rep1e1_pos} \prec \text{rep1e2_pos} \prec \text{rep2e2_pos}$

A case such as $\text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep1e2_pos} \prec \text{rep2e2_pos}$ should automatically be excluded since it's a classification error. Any order specification between any element in **rep1** and **rep2** would be sufficient to infer the all orders with transitivity. For example, asserting `before(rep1e1_pos, rep2e1_pos)` would allow a reasoner to infer Case 1 from above.

In Figure 4.10, the positions of elements in **rep1**, i.e., **rep1e1_pos** and **rep1e2_pos**, are defined with the following predicates:

rep1: `before(rep1e1_pos, rep1e2_pos), before(rep1e1_pos, rep2e1_pos), after(rep1e2_pos, rep2e2_pos).`

Assuming no information regarding the position of elements in **rep2**, the following order can be inferred by transitivity:

$\text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep2e2_pos} \prec \text{rep1e2_pos}.$

Since the order between **rep2e1_pos** and **rep2e2_pos** is unknown, we have the following possible cases:

$\text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep2e2_pos} \prec \text{rep1e2_pos}$

$\text{rep1e1_pos} \prec \text{rep2e2_pos} \prec \text{rep2e1_pos} \prec \text{rep1e2_pos}$

$\text{rep2e2_pos} \prec \text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep1e2_pos}$

...

Note that only the first two cases are reversed repetitions. Now suppose we work from the positions of elements in **rep2**, i.e., **rep2e1_pos** and **rep2e2_pos**:

rep2: `before(rep2e1_pos, rep2e2_pos), before(rep1e1_pos, rep2e1_pos), before(rep2e2_pos, rep1e2_pos).`

The following order can be inferred by transitivity:

$\text{rep1e1_pos} \prec \text{rep2e1_pos} \prec \text{rep2e2_pos} \prec \text{rep1e2_pos}.$

There is only one case of ordering possible, even without the knowledge of the order of **rep1e1_pos** and **rep1e2_pos**. The inferred predicate `before(rep1e1_pos, rep1e2_pos)` is shown as dashed in Figure 4.10.

Based on the observation above, the positions of elements in an instance of **ReversedRep** can be inferred by transitivity when the positions of elements of the inner most instance of **ReversedRep** is ordered. For a general case $a_1 a_2 a_3 \dots a_{n-1} a_n a_n a_{n-1} \dots a_3 a_2 a_1$, if the inner

most antimetabole $a_{n-1}a_na_na_{n-1}$ is ordered, and $a_{n-2}a_{n-1}a_{n-1}a_{n-2}$ is also ordered, then a reasoner can infer $a_{n-2}a_{n-1}a_na_na_{n-1}a_{n-2}$ by transitivity.

Positions are stand alone individuals that are connected to instances of **Element**. Therefore ordering roles such as **before** and **after** can be assigned to **Elements** based on different **Repetitions**.

Gradatio Rep

A GradatioRep

- is a subclass of **N1Rep**
- has at least 2 **hasEle** in which the values are instances of **Cross-Boundary-Rep** which is a subclass of **SingleRep**

$$\begin{aligned} \text{GradatioRep} \Rightarrow \langle \{ & \text{GRADATIOREP}/(\text{self}), \\ & \{ \forall e. \text{GRADATIOREP}(e) \rightarrow \text{N1REP}(e), \\ & \forall e_1. \text{GRADATIOREP}(e_1) \rightarrow \\ & \exists e_2, e_3. \text{HASELE-N1}(e_1, e_2) \\ & \wedge \text{HASELE-N1}(e_1, e_3) \\ & \wedge \text{CROSS-BOUNDARY-REP}(e_2) \wedge \text{CROSS-BOUNDARY-REP}(e_3) \} \} \rangle \end{aligned}$$

Since it is possible that the two anadiploses intersects each other, e.g., the case ... a b, a b ... in which ... a, a ... and ... b, b ... are considered as two individual anadiploses⁵. This is due to the vagueness in the definition of a boundary. A loosely defined boundary may confuse the classification of a plope, while a strictly defined boundary may overlook a plope. A more strict constraint on the positions of elements of e_2 and e_3 can be applied to ensure the Plope Ontology captures a **GradatioRep**.

⁵Note that ... a b, a b ... can also be an anadiplosis if one chooses a b as the token.

$$\begin{aligned}
\text{GradatioRep} \Rightarrow \langle \{ & \text{GRADATIOREP}/(\text{self}) \}, \\
& \{ \forall e. \text{GRADATIOREP}(e) \rightarrow \text{N1REP}(e), \\
& \forall e_1. \text{GRADATIOREP}(e_1) \rightarrow \\
& \exists e_2, e_3, e_2p, e_2p', e_3p, e_3p', c_1, c_2. \text{HASELE-N1}(e_1, e_2) \\
& \wedge \text{HASELE-N1}(e_1, e_3) \\
& \wedge \text{CROSS-BOUNDARY-REP}(e_2) \wedge \text{CROSS-BOUNDARY-REP}(e_3) \\
& \wedge (\text{HASELE-S}(e_2, -) \wedge \text{HASPOS}(-, e_2p)) \\
& \wedge (\text{HASELE-S}(e_2, -) \wedge \text{HASPOS}(-, e_2p')) \\
& \wedge (\text{HASELE-S}(e_3, -) \wedge \text{HASPOS}(-, e_3p)) \\
& \wedge (\text{HASELE-S}(e_3, -) \wedge \text{HASPOS}(-, e_3p')) \\
& \wedge \text{POSITION-ORDER}(e_2p', e_3p) \\
& \wedge \text{POS-CLAUSE}(e_2p, c_1) \wedge \text{POS-CLAUSE}(e_3p', c_2) \\
& \wedge \text{CLAUSE}(c_1) \wedge \text{CLAUSE}(c_2) \\
& \wedge \text{CLAUSE-ORDER}(c_1, c_2) \} \rangle
\end{aligned}$$

The constraint $\text{POSITION-ORDER}(e_2p', e_3p)$ neglects the case of ... a b, a b Another constraint $\text{POS-CLAUSE}(e_2p, c_1) \wedge \text{POS-CLAUSE}(e_3p', c_2)$ states that the elements of cross-boundary repetitions e_2 and e_3 must be in different clauses to ensure the pattern of ... a, a ... b, b Note that the constraint states that only the position of the first element of e_2 , i.e., e_2p , must be in c_1 , and the position of the second element of e_3 , i.e., e_3p' , must be in c_2 , since it is possible for e_2p' and e_3p to be in the same clause as in the case of ... a, a ... b, b Thus the constraint $\text{POS-CLAUSE}(e_3p, c_2)$ is unnecessary but the constraint $\text{POS-CLAUSE}(e_3p, c_2)$ is necessary.

4.9 Examples

This section shows a number of examples using the representation outlined in the Ploke Ontology. This section includes examples in the form of both real literature and abstract strings.

Example 1: Path

Recall [Example 2.1.1](#):

all for one, one for all

I have discussed some of the instances of [Example 2.1.1](#) in Section 4.8.1. Below are the complete predicates to represent [Example 2.1.1](#) in terms of the Ploke Ontology.

```
NestedRep(revRep1)
hasEle(revRep1, rep1)
hasEle(revRep1, rep2)
hasEle(rep1, rep1e1)
hasEle(rep1, rep1e2)
hasEle(rep2, rep2e1)
hasEle(rep2, rep2e2)
SingleRep(rep1)
SingleRep(rep2)
```

```
hasPos(rep1e1, rep1e1_pos)
hasPos(rep1e2, rep1e2_pos)
hasPos(rep2e1, rep2e1_pos)
hasPos(rep2e2, rep2e2_pos)
before(rep1e1_pos, rep2e1_pos)
before(rep2e1_pos, rep2e2_pos)
before(rep2e2_pos, rep1e2_pos)
```

The `hasEle.hasEle.refersTo` property chain forms a path that connects an instance of `ReversedRep` with an instance of a `Token`.

```

hasEle.hasEle.refersTo(revRep1, all)
hasEle.hasEle.refersTo(revRep1, one)

```

The paths above have the same path but with different end vertices, i.e., `all` and `one`. This is due to the common property of `hasEle`. Similar to a `hasChild` property, an instance may have many children. It is possible to expand `hasEle` to a set of sub-properties `hasElei` where $1 \leq i \leq n$. Then each path points to a unique `Element`, i.e., `rep1e1`, `rep1e2`, `rep2e1`, or `rep2e2`, via a unique `hasElei.hasElej...hasElek.refersTo` path.

Example 2: Meaningful Representation

Given a passage `abbcaddc`, in which each character ‘a’, ‘b’, or ‘c’ is a token. We demonstrate multiple representation methods of this passage using the Ploke Ontology. See Figure 4.15 to 4.17.

- All instances of `NestedRep` can be flattened into a single layer of `SingleRep` with only one `NestedRep` as the root. See Representation 2 in Figure 4.16. However this representation may not be meaningful since it does not capture nested plokies like `antimetabole` and `gradatio`
- One may ask: are `antimetabole` and `gradatio` the only nested plokies? Each of them requires only one level of `NestedRep`, although being able to represent multiple levels of `NestedReps` is more expressive and flexible to represent types of repetitions. E.g., a *repeated antimetabole* is captured by `nrep4` in Representation 1 in Figure 4.15 with `nrep3` the `gradatio` removed. The repeated antimetabole does not correspond to any ploke figure. It is an abstracted repetition that may act as a wrapper for the `N1Reps`.

Representation 1

```

nrep1 = an antimetabole abba (k = 1)
nrep2 = an antimetabole cddc (k = 1)
nrep3 = a gradatio b,b...d,d (k = 1)
nrep4 = the repetition of nrep1, nrep2, and nrep3 (k = 2)

```

This representation captures two antimetaboles and one gradatio.

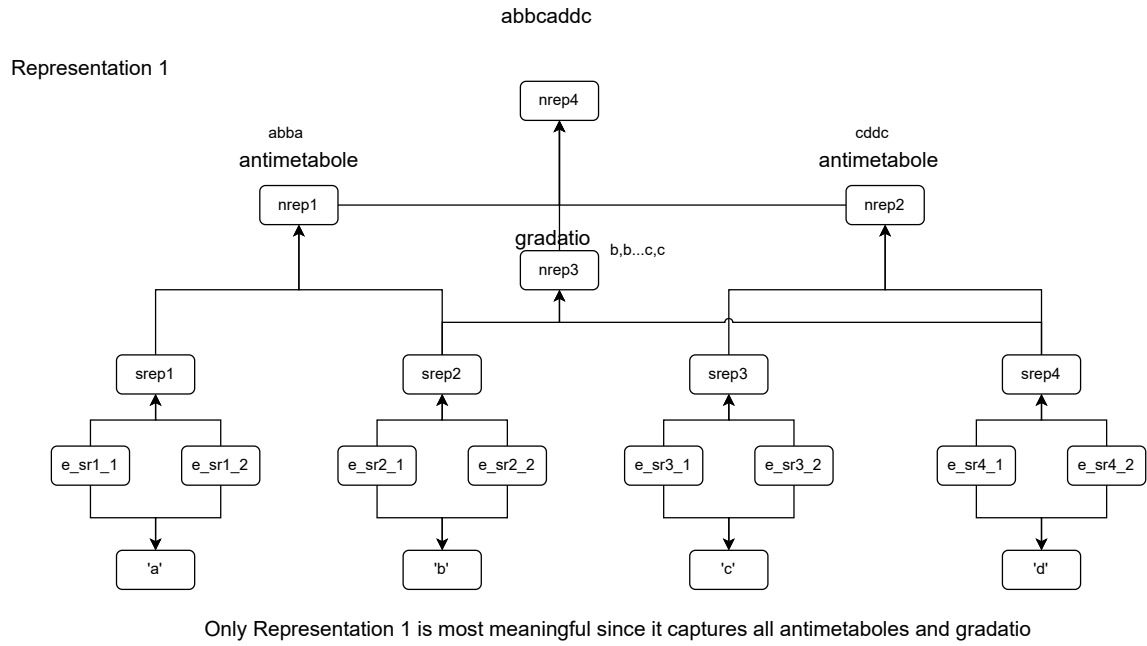


Figure 4.15: Representation 1 of abbcaddc

Representation 2

$\text{srep1} = \text{aa} \ (k = 0)$

$\text{srep2} = \text{bb} \ (k = 0)$

$\text{srep3} = \text{cc} \ (k = 0)$

$\text{srep4} = \text{dd} \ (k = 0)$

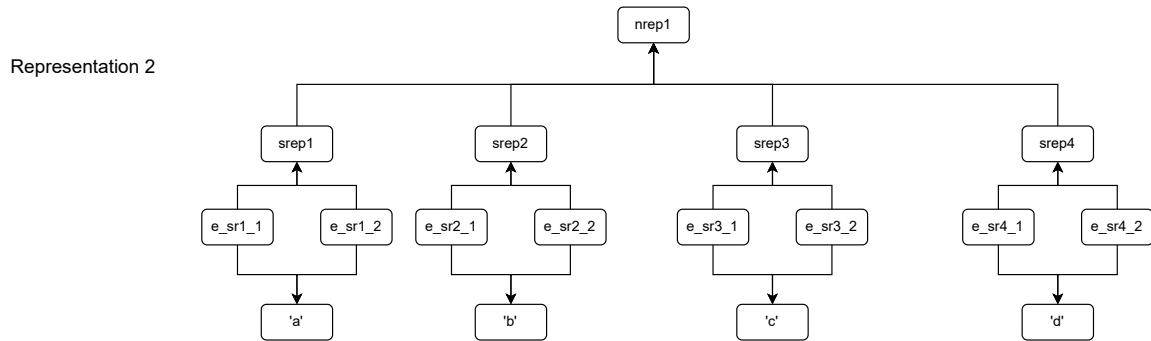
$\text{nrep1} = \text{the repetition of srep1, srep2, srep3, and srep4} \ (k = 1)$

This is a flat representation that does not capture any of the antimetaboles and gradatio.

Representation 3

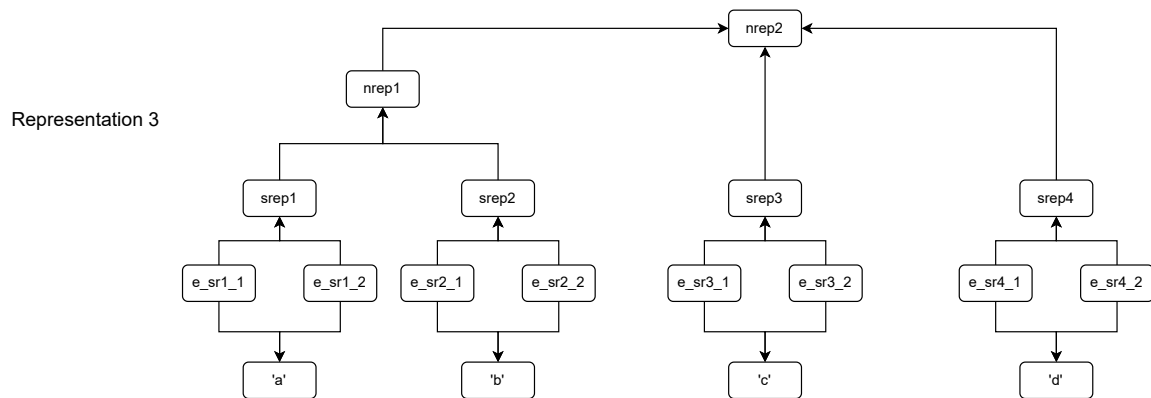
$\text{nrep1} = \text{an antimetabole abba} \ (k = 1)$

$\text{nrep2} = \text{the repetition of nrep1, srep3, and srep4} \ (k = 2)$



Representation 2 is the flattened representation, which is still acceptable but not meaningful since it does not capture any nested plokes

Figure 4.16: Representation 2 of abbcaddc



Representation 3 is an acceptable representation but not as meaningful as 1 since it captures only one antimetabole

Figure 4.17: Representation 3 of abbcaddc

This representation captures only one antimetabole.

There are multiple ways to represent each passage using the Ploke Ontology. There is no correct ways of representation and a meaningful representation is specific to use-cases.

Example 3 Choice of Tokens

Example 3.1: abccba

Antimetabole is basically a palindrome, e.g., `abc...cba`. Each ‘a’, ‘b’, and ‘c’ can be treated as an individual token, see top part of Figure 4.18. In this case, `nrep1` is an instance of `N1Rep` which in turn is a subclass of `NestedRep`. The instance `nrep1` resembles the antimetabole `abc...cba`.

Another possible representation is to assign an instance of `N1Rep`, `nrep1 = ab...ba`, which includes `srep1 = a...a` and `srep2 = b...b`. Then `srep3 = c...c`, then a `nrep2`, an instance of `N2Rep` combines `nrep1` and `srep3`. In this case `nrep1` is an antimetabole `ab...ba`. `nrep2` is an abstract nested repetition. Similarly, let `nrep1 = ac...ca` and `srep3 = b...b` is also a valid representation.

The representation will also change if different tokens are selected. E.g., if `token=ab,ba` and ‘c’ then there is no antimetabole in `abccba` since it is a pattern of `XYYZ` ($X = ab, Y = c$, and $Z = ba$) instead of a `XYZZYX` pattern as when ‘a’, ‘b’ and ‘c’ are used as tokens. That is, `(ab)cc(ba)` is not an antimetabole in this representation since `ab` and `ba` do not form a repetition. A `NestedRep` takes `Repetitions` as elements, not a specific figure. However, it is possible to construct a class in the Ploke Ontology, say, `NestedAntimetabole`, in which elements are restricted to instances of `ReversedRep` which are triggered by the forms of antimetaboles.

Example 3.2: abccab

Consider `ab` and ‘c’ as the tokens. To represent an antimetabole `abccab` where `ab` and ‘c’ form the reversed repetition, a level of `NestedRep` is needed for `ab` (repeated ‘a’ and ‘b’). See Figure 4.19.

It is incorrect to classify `nrep2` as a reversed repetition (an antimetabole) on the left half of Figure 4.19. `nrep2` is a reversed repetition only if its elements are single repetitions of `ab` and ‘c’, as shown on the right side of Figure 4.19. This way it creates a form of `XYXX` where $X = ab$ and $Y = c$. The `nrep2` on the left of Figure 4.19 has a form of `XYZZXY` where $X = a$, $Y = b$, and $Z = c$, which is not a reversed repetition. Note that `nrep2` on the left has instances of both `NestedRep` and `SingleRep` as elements. It is still a nested repetition.

An antimetabole `a...c...c...a...` can also be represented when tokens are ‘a’ and ‘c’.

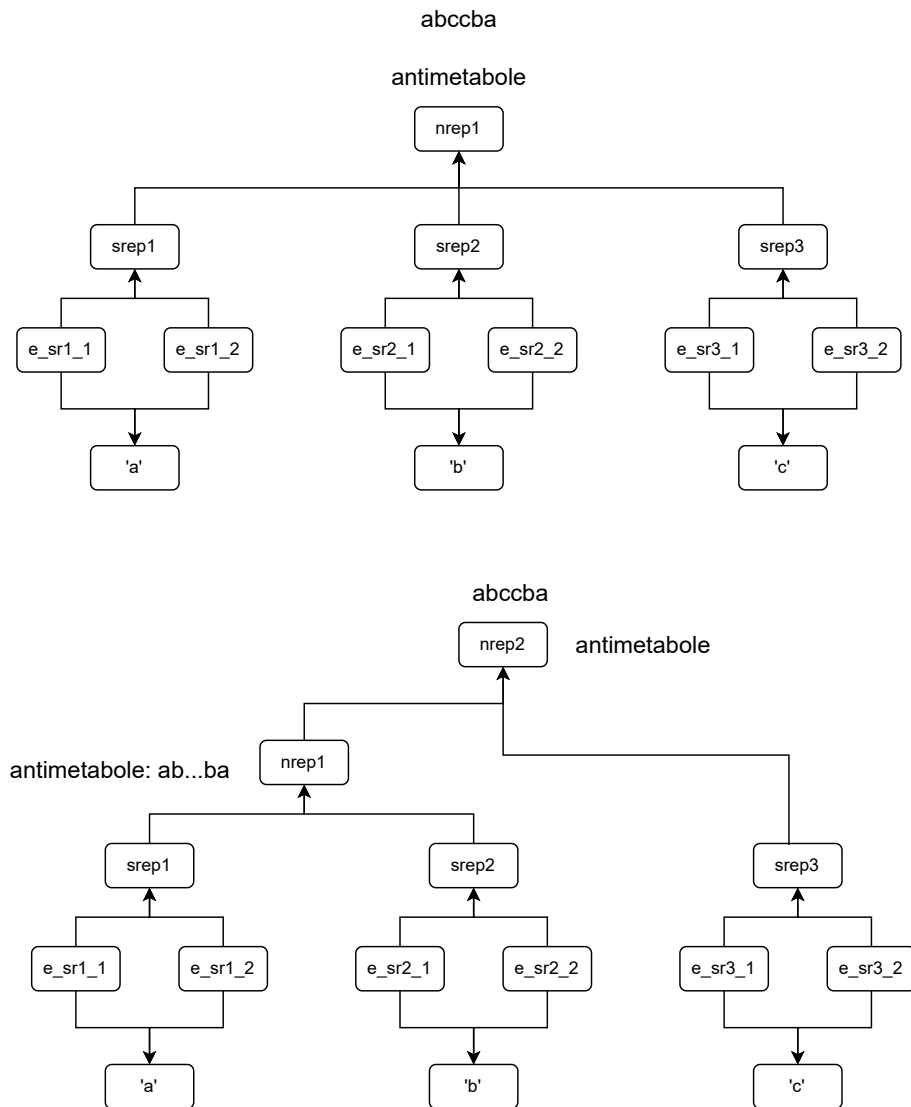


Figure 4.18: Two cases of antimetabole representation using **NestedRep** for abccba.

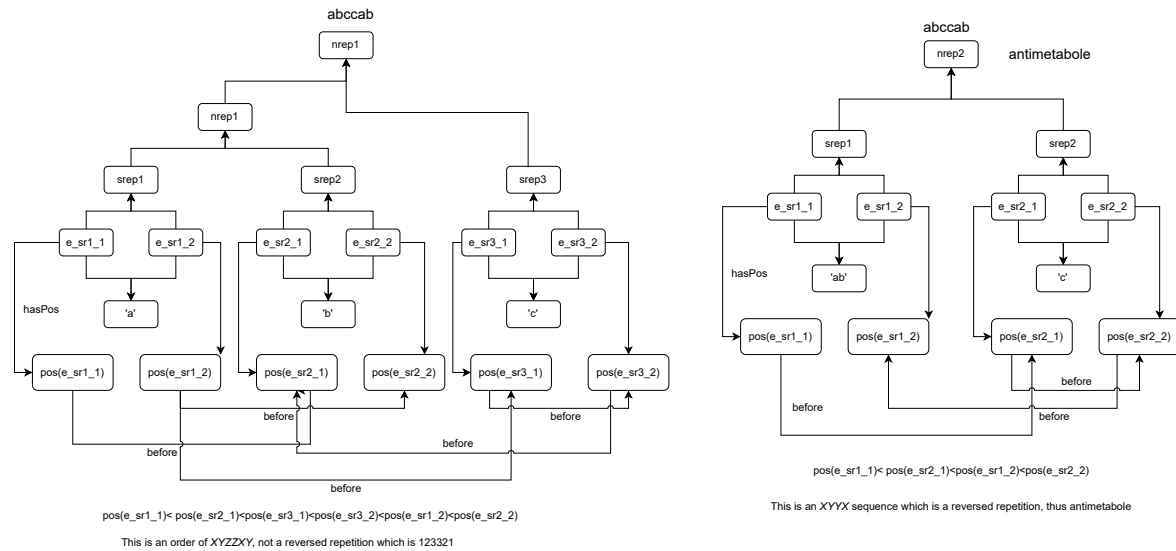


Figure 4.19: Two representations of **abccab**. Only **nrep2** captures an antimetabole.

Example 3.3: **ab...ab**

The same can be demonstrated by the case of epanalepsis, **ab...ab**. If the token is **ab**, we have a single repetition which is an instance of **Clause-Outer Repetition**, an epanalepsis. If the tokens are ‘**a**’ and ‘**b**’ then we have a nested repetition that does not assemble epanalepsis, Then it is an abstract nested repetition.

There are multiple representation of the same repetition, using **SingleRep** or **NestedRep**. But for pokes we care about only the *meaningful* ones that are triggered by **PlokeForms**, i.e., the **SingleReps**, **ReversedReps** and **GradatioReps**. It is possible to find a way to infer representations are equivalent as future work. Both **ReversedRep** and **GradatioRep** are level 1 **NestedReps**, i.e., **N1Reps**. Higher level nested repetitions can be used to create abstract repetitions that do not corresponds to a plope. Being able to construct abstract repetitions is important for expressing relations between multiple pokes. It can also be extended to establish connections among rhetorical figures other than plope and may be used to express newly invented figures in future.

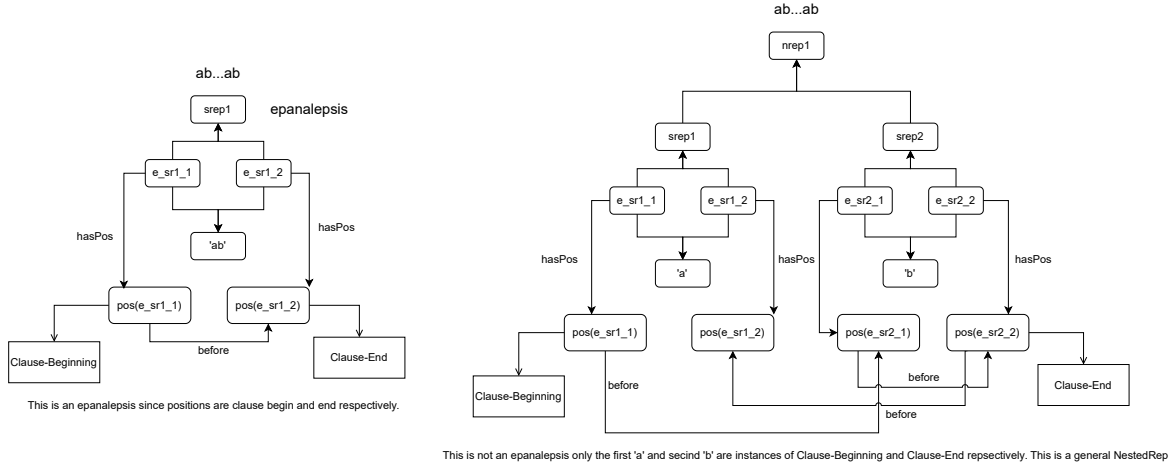


Figure 4.20: Two representations of $ab \dots ab$. Only **srep1** on the left captures an epanalepsis.

4.10 Summary

The Ploke Ontology given in this thesis is the first KR model that formally represents the knowledge and concepts associated with the concept of Ploke. Capturing this ontology with the combination of the EER diagram and its mapping to first-order theories provides a formal framework for the Ploke Ontology. As a consequence of the underlying first-order theory, it becomes possible to explore formal verification with the use of theorem provers. This verification includes consistency checking and testing whether an instance is indeed a ploke. With regard to validation, the Ploke Ontology was constructed in collaboration with domain experts in rhetorical figures. A possible direction for future validation work is to conduct an experiment with more domain experts of rhetorical figures to test the representation results of artificial examples shown in Section 4.9 on real-world examples. Although perfect lexical repetition is guaranteed with the **Token** class, the ability to avoid lexical repetitions that are not pokes such as polyptoton or antanacsis should also be validated when the Ploke Ontology is implemented as part of a specific application.

The Ploke Ontology focuses on the concept of Ploke which is a sub-concept of rhetorical figure. Thus, the Ploke Ontology will be implemented in the future as one of the rhetorical figure ontologies envisaged by the RhetFig/Rhetoricon project [105]. The rhetorical figure ontologies may resemble a structure similar to that of the PolisGnosis project [73, 74, 216, 217] which also consists of a series of interconnected ontologies of the domain of Global City

Indicators [72, 218, 221]. As outlined by the methodology of design and evaluation of such ontologies [90], the rhetorical figure ontologies should not be isolated from other existing ontologies nor each other. Thus, rhetorical figure ontologies should establish connections to foundational or upper ontologies [91, 173], as well as to ontologies in the domain of linguistics and rhetoric. In Chapter 5, Section 5.2 demonstrates the process to merge the Ploke Ontology with two rhetorical figure ontologies developed for Serbian, i.e., RetFig [166], and for German, i.e., GRhOOT [133].

Chapter 5

Applications

5.1 Ploke Instances in ARM

Borgida, Toman, and Weddell [25, 26], and Ma et al. [146] have proposed an *abstract relational model* (ARM) and an extension to SQL called *SQL with paths* (SQLP), which make it possible to capture a conceptual understanding of information from data source, query the information in a way similar to SQL, and address identity issues. Below is the definition for an ARM schemata from Ma et al. [146]. Please refer to papers cited in this paragraph for further readings about ARM and SQLP.

Let TAB, AT, and CD be sets of table names, attribute names, that includes **self**, and *concrete domains* (data types), respectively, and let OID be an *abstract domain of entities (surrogates)*, disjoint from all concrete domains. A *general relational model schema* Σ is a set of *table declarations* of the form¹ **table** T ($A_1 D_1, \dots, A_k D_k, \varphi_1, \dots, \varphi_\ell$), where $T \in \text{TAB}$, $A_i \in \text{AT}$, $D_i \in (\text{CD} \cup \{\text{OID}\})$, and φ_j are *constraints* attached to table T . We write $\text{ATTRS}(T)$ to denote $\{A_1, \dots, A_k\}$ and $\text{TABLES}(\Sigma)$ to denote all table names declared in Σ . A_i is *abstract* if D_i is **OID**, and *concrete* otherwise, and **self** must always be abstract. In addition to attribute declarations “($A_i D_i$)”, a variety of constraints φ_j can occur in a table declaration of T , e.g.,

1. (*primary keys*) **primary key** ($A_1, \dots, A_k$)
2. (*foreign keys*) **constraint** N **foreign key** ($A_1, \dots, A_k$) **references** T

¹This is essentially the syntax for SQL’s **create table** commands.

3. (*inheritance*) `isa` T_1
4. (*disjointness constraints*) `disjoint with` $(T_1, \dots, T_k)$
5. (*path functional dependencies*) `pathfd` $(Pf_1, \dots, Pf_k) \rightarrow Pf$

In practice, an instance `passage1` of a `Passage` such as `all for one`, `one for all` can be annotated with subclasses of pokes such as `epanalepsis`, `anadiplosis`, `antimetabole` and `mesodiplosis` by indicating the words being repeated, i.e., `all`, `for`, `one`. In a relational DB this could be annotated with a JSON entry indicating the repeated words and their positions. However, this shallow representation in a relational model does not resemble the power of the Ploke Ontology in which repetitions are explicitly represented as instances of `Element` which refers to an instance of a `Token` and has a `Position`.

For example, the conceptual model provided by the Ploke Ontology is able to infer the following statements:

Setup:

- Let instances of `Token` contained in `passage1` be: `all`, `for`, and `one`.
- Let instances of `Element` be `e-all-1`, `e-all-2`, both refer to `all`.
- Setup `e-for-1`, `e-for-2`, `e-one-1`, `e-one-2` similarly.

Inference:

- `passage1` contains the following instances `epana1` of `Epanalepsis`, `meso1` of `Mesodiplosis`, `anad1` of `Anadiplosis`, and `anti1` of `Antimetabole`
- Each instance has a `Form`: `epana-form1`, `meso-form1`, `anad-form1`, and `anti-form1`
- Each instance of `Form` triggers an instance of `Repetition`, i.e., `epana-srep1`, `meso-srep1`, `anad-srep1`, and `anti-nrep1`. Note that names with `srep` are instances of `SingleRep`, names with `nrep` are instances of `NestedRep`
- Each instance of `Repetition` has corresponding elements mentioned above. For example, `epana-srep1` has elements `e-all-1` and `e-all-2`.
- The instance `anti-nrep1` of `NestedRep` has `epana-srep1` and `anad-srep1` as its elements.

- A instance of N2Rep can be created with elements `anti-nrep1` and `meso-srep1` to represent the nested repetition contained in `passage1`

Information above can be used to provide the output of a user question: explain the plope figures in `passage1`.

In a RM model, for example, this relation can be obtained by joining foreign keys from multiple tables. Suppose there are three tables `FIGURE`, `EXAMPLE`, and `EXAMPLEFIGURE` to store rows of data about rhetorical figures, example passages, and passages annotated according to rhetorical figures, respectively. The passage has a Primary Key `EXAMPLE.id`, and a column `Entry` to store the actual string. It requires a separate `EXAMPLEFIGURE` table to state the relation between a passage with a rhetorical figure and its corresponding annotation. A column `EXAMPLEFIGURE.annotation` which is a JSON entry to display annotation for the passage for a specific `FIGURE.id`. Another column `EXAMPLE.FigureID` joins with `FIGURE.ID` to obtain the rhetorical figures contained in this entry. For example, the following rows are part of the sample database. Note that `FigureID=FIGURE.id` refers to a foreign key mapping:

Assuming `Example.id=1` is the entry “all for one, one for all”, `FIGURE.id` 1 to 4 are Anadiplosis, Antimetabole, Epanalepsis, and Mesodiplosis, respectively.

`EXAMPLE` table:

```
EXAMPLE.id = 1, Entry (string)="all for one, one for all"
```

`EXAMPLEFIGURE` table:

```
{EXAMPLEFIGURE.id = 1, ExID=EXAMPLE.id=1,
  FigureID=FIGURE.id=1, annotation JSON}
{EXAMPLEFIGURE.id = 2, ExID=EXAMPLE.id=1,
  FigureID=FIGURE.id=2, annotation JSON}
{EXAMPLEFIGURE.id = 3, ExID=EXAMPLE.id=1,
  FigureID=FIGURE.id=3, annotation JSON}
{EXAMPLEFIGURE.id = 4, ExID=EXAMPLE.id=1,
  FigureID=FIGURE.id=4, annotation JSON}
```

The RM model lacks the following details:

- It does not provide an explicit general definition on plokcs and map the relation between each plope figure and each subtype of repetition. The annotation is specific to each passage without a general knowledge.

- It is able to link a passage with a rhetorical figure and an annotation without being able to explain the annotation according to definitions of rhetorical figures.
- It shows that there are multiple rhetorical figures in the same entry, but cannot provide the relations among these rhetorical figures.
- It cannot answer competency question such as: Does `passage1` (`EXAMPLE.id = 1`) contain plope? This question is trickier than it looks since according to the RM model, none of which indicates it contains a plope since there is no hierarchical relation defined between the rhetorical figures antimetabole, mesodiplosis, etc. and plope. In contrast, the Plope Ontology is able to infer the relation as shown above.
- It is merely an indication rather than an explanation.

One can take advantage of a portion of the representation and the power of inference of the Plope Ontology by adapting to an ARM schema, which can be transformed in a RM schema via referring expression types and assignments [25, 26, 146]. In ARM, the table PLOKE can have a `isa` constraint that points to the FIGURE table. It has the following attributes, * means it's an abstract attribute.

```
table PLOKE (self OID, form OID, passage STR)
  isa FIGURE
  constraint form foreign key (form) references FORM

table ANADIPLOSIS (self OID, form OID, passage STR)
  isa PLOKE
  constraint form foreign key (form) references FORM

table ANTIMETABOLE (self OID, form OID, passage STR)
  isa PLOKE
  constraint form foreign key (form) references FORM
```

The positions of elements in an antimetabole need to form a reversed order. This can be achieved using path functional dependencies (PFD) [114, 214, 222, 223].

For a reversed repetition `abba`, which has elements `rep-a` and `rep-b`, which in turn have elements `a1`, `a2`, `b1` and `b2` correspondingly. The element before `b1` and the element after `b2` must be both from `rep-a`. In general, in a repetition *rep* that is an element of a

reversed repetition *revrep*, its elements *e1* and *e2* must be *after* and *before*, respectively, the elements of the repetition *rep*, which is an element of the same reversed repetition *revrep*. I assume that *hasEle1* points to *e1*, *hasEle2* points to *e2* and *before(e1,e2)*.

$$\begin{aligned} \text{PFD for revrep: } & \text{hasEle1.hasPos.before}^{-1}.\text{hasPos}^{-1}.\text{hasEle}^{-1} \\ & \rightarrow \text{hasEle2.hasPos.before.hasPos}^{-1}.\text{hasEle}^{-1} \end{aligned}$$

This PFD can be repeatedly applied for cases with more than two single repetitions, e.g., $a_1a_2a_3\dots a_{n-1}a_na_na_{n-1}\dots a_3a_2a_1$. For the case of a_1 , both side of the PFD will be null since there is no *before* and *after* for elements *e1* and *e2* that refer to a_1 .

The ARM schema for concepts related to Repetition is demonstrated below.

```
table FORM (self OID, fig OID, rep OID)
  constraint figure foreign key (fig) references FIGURE
  constraint repetition foreign key (rep) references REPETITION

table REPETITION (self OID, hasEle OID)
  constraint element foreign key (hasEle) references ELEMENT

table SINGLEREP (self OID, element OID)
  constraint element foreign key (element) references ELEMENT
  pathfd element.token → self
  isa REPETITION

table N1REP (self OID, element OID)
  constraint element foreign key (element) references SINGLEREP
  pathfd element.token → self
  isa REPETITION

table N2REP (self OID, element OID)
  constraint element foreign key (element) references N1REP
  pathfd element.token → self
  isa REPETITION

table N3REP (self OID, element OID)
  constraint element foreign key (element) references N2REP
```

```

pathfd element.token → self
isa REPETITION

```

```

table ELEMENT (self OID, token OID, pos OID)
  constraint token foreign key (token) references TOKEN
  constraint position foreign key (pos) references POSITION

```

I simplified attributes `token` and `pos` to `STR` and `INT` to simplify the examples.

Suppose a user query looks for rhetorical figures involved with the token `one`. Then, in SQLP [145, 146]:

```

select fig FROM PLOKE p WHERE
  p.form.rep.element.token="one"

```

Query elements involved in both an anadiplosis and an antimetabole.

```

select anad.form.rep.element, anti.form.rep.element
  FROM ANADIPLOSIS anad, ANTIMETABOLE anti
  WHERE
    anad.form.rep.element=anti.form.rep.element.element

```

Note that the element of the repetition triggered by the form of an antimetabole can be accessed by `anti.form.rep.element.element` since a reversed repetition is under the table `N1REP`. Similarly, an element of `N2REP` and `N3REP` can be accessed by, for example,

```

plope.form.rep.element.element.element
and
plope.form.rep.element.element.element.element
respectively.

```

The question is that the `hasElement` relation has a cardinality restriction of ≥ 2 . Therefore in an ARM schema this will result in multiple rows with different values on the `hasElement` column for each repetition in which each element references to its self value in the `ELEMENT` table.

5.2 An Unified Multilingual Ontology

This section describes the work to merge the Ploke Ontology and two of the previously mentioned rhetorical figure ontologies: the RetFig and GRhOOT ontologies, initiated in Wang et al. [220]. The goal of merging these three ontologies is to demonstrate that rhetorical figure ontologies developed separately can be connected together. Also by merging the Ploke Ontology with rhetorical figures developed for different languages, such as the Serbian RetFig and the German GRhOOT ontologies, it shows that information represented in the Ploke Ontology is indeed independent of language and can incorporate features from different languages. Note that the terms rhetorical figure of perfect lexical repetition and plope are distinguished in this section and in this section only, since the three ontologies have different definitions for these two terms.

The merging of the three ontologies focus on multilingual aspects, formal categorization, and neurocognitive affinities. As stated by Wang et al. [220], the RetFig and GRhOOT ontologies are the only known non-English ontologies that formally model rhetorical figures, but they do not include the effects or purposes of rhetorical figures. However, GRhOOT already includes multilingualism as it is a translation and adaption of the Serbian RetFig. The merging of multilingual ontologies focuses on rhetorical figures of perfect lexical repetition as they are extra-grammatical and neuro-cognitively motivated and are therefore language independent. The Ploke Ontology is a perfect choice, as it models figures of perfect lexical repetition in English and includes neurocognitive aspects. Therefore, the Ploke Ontology should be able to incorporate language features specific to the Serbian and German ontologies. Furthermore, all three ontologies aim to be combined with other ontologies as future work and they were already modeled to allow an extension or adaption.

5.2.1 Inconsistencies of the Ontologies

This section discusses how the ontologies are fit or unfit to be connected, and the steps taken to alter any incompatible components in the ontologies. However, each ontology was modeled differently and inconsistencies or deviations are expected. The Ploke Ontology serves as a baseline since it models the most specific rhetorical figure concepts among the three ontologies.

Table 5.1 shows the definitions of rhetorical figures of perfect lexical repetition in the three ontologies.

For each figure of perfect lexical repetition, the comparison was made within the three ontologies if it exists in the other languages in general and if it is modeled in the ontologies,

Figure	Language	Definition
Anadiplosis	English	The repetition of a word or word group on both sides of a clause or phrase boundary.
Anadiplose	German	Repetition of the last word of a sentence at the beginning of the next sentence.
Palilogija	Serbian	Repetition of the words at the end of a verse at the beginning of the next verse.
Conduplicatio	English	Unpatterned perfect lexical repetition.
Epanalepse	German	Repetition of a word or group of words in a sentence [62].
Epanalepsis	English	The repetition of a word or word group at the beginning and ending of the same clause or phrase.
Epanadiplose	German	Repetition of a word at the beginning and end of a sentence/line.
Okruzivanje	Serbian	The same word is at the beginning and end of the sentence (verse).
Epanaphora	English	The occurrence of the same word or word group at the beginning of proximal clauses or phrases.
Anapher	German	Repetition of the word in the beginning in successive sentences.
Anafora	Serbian	Repetition of the same words in the beginning (verse).
Epiphora	English	The occurrence of the same word or word group at the end of proximal clauses or phrases.
Epipher	German	Inversed anaphora.
Epifora	Serbian	Repetition of the same words at the end (verses).
Epizeuxis	English	The immediate repetition of a word or word group with no other words intervening.
Epizeuxis	German	Three or more repetitions of the same word/word group.
Epizeusa	Serbian	Repeating the same word several times in the same sentence or verse for emphasis.
Gradatio	English	A sequence of anadiploses.
Gradation	German	Gradual increase, top term for climax/anticlimax.
Gradacija	Serbian	Transferring one word or word group from one sentence or verse to the next sentence or verse in order to gradually increase or decrease the strength of the initial statement.
Mesodiplosis	English	Lexical repetition of a word or word group in the middle of clauses or phrases.
Symploce/Symploke	English	Combination of epanaphora and epiphora: The occurrence of the same word or word group at the beginnings of two or more proximal phrases or clauses while another word or word group occurs at the ends of those same phrases or clauses.
Symploke	German	Combination of anaphora and epiphora.
Simploka	Serbian	Repetition of the same words at the beginning and at the end (verses).
Anaklaza	Serbian	Repeating the same word in the same verse for emphasis.
Antiklimax	German	Downward gradatio.
Emphase	German	Emphatic emphasis of a word, often acoustically or with exclamation marks.
Emfaza	Serbian	Emphasis on words in a sentence. Exaggeration in the tone or expression with which the writer or speaker emphasizes certain words, thoughts or feelings. It can turn into force.

Table 5.1: Explanation of figures in different languages. Adapted from Wang et al. [220].

too. The result is shown in Table 5.2. A dash indicates that a figure does not exist in this ontology.

Some figures such as *anaklaza*, *mesodiplosis*, or *antiklimax*, are only modeled in one ontology or only in one of the ontologies considered as a subclass of **Ploke**. Only in GRhOOT, *antiklimax* is considered as a rhetorical figure of perfect lexical repetition, but *klimax* (climax) is not. It is questionable if this is just due to a wrong classification. One might

Ploke Ontology	Serbian RetFig	German GRhOOT
Anadiplosis	Palilogija	Anadiplose
Conductuplicatio	–	Epanalepse
Epanalepsis	Okruzivanje	Epanadiplose
Epanaphora	Anafora	Anapher
Epiphora	Epifora	Epipher
Epizeuxis	Epizeusa	Epizeuxis
Gradatio	Gradacija	Gradation
Mesodiplosis	–	–
Symploke	Simploka	Symploke
–	Anaklaza	–
–	–	Antiklimax
–	Emfaza	Emphase

Table 5.2: Comparison of figures of perfect lexical repetition. Adopted from Wang et al. [220].

notice, for instance, that *epanalepsis* is not the same as the German figure *epanalepse*, but *epanadiplose*. The terminology of rhetorical figures is notoriously inconsistent. Wang et al. [220] looked further into the definitions to spot differences and detect inconsistencies. Table 5.1 provides the definitions from each ontology for the respective figure: the English definitions [104] that are used in the Ploke Ontology, the German definitions [20] from GRhOOT, and the Serbian definitions from the RetFig ontology.

The following subsections discuss types of inconsistencies between RetFig/GRhOOT and the Ploke Ontology. These inconsistencies fall under a more general classification of heterogeneity outlined by Euzenat and Shvaiko [66]. Wang et al. [220] adapts those types of heterogeneity to introduce the following types of inconsistencies.

5.2.2 Model Inconsistency

Model inconsistency is a type of conceptual or semantic heterogeneity, particularly an instance of *difference in granularity* or *difference in perspective* [66]. The difference is caused by the level of detail represented for concepts in each ontology. The most significant inconsistency is that rhetorical figures are modeled as individuals in GRhOOT, but are modeled as classes in the Ploke Ontology. The former focuses on the relation of rhetorical figures with linguistic entities in general, in which it is sufficient to represent each rhetorical figure as an individual. The latter models a specific class of figures, i.e., ploke, which

requires the representation of the hierarchical relations between **Ploke** and its subclasses, and their relations to corresponding subclasses of **Repetition** and **Position**. For example, in GRhOOT, the figure epizeuxis is represented by an individual **epizeuxis**, an instance of the class **RhetoricalFigure**, with axioms shown in Table 5.3. In the Ploke Ontology, the figure epizeuxis is represented by a class **Epizeuxis**, an indirect subclass of the class **RhetoricalFigure**. An instance of **Epizeuxis** is an individual representing a specific epizeuxis, e.g., **epiz1**, which is connected to **epiz1form** and **immediateRep1** which are instances of the **EpizeuxisForm** and **ImmediateRepetition**, respectively. The relations are outlined in Figure 5.2.

In order to resolve this inconsistency, classes that are defined in the Ploke Ontology will replace the corresponding individuals in GRhOOT while maintaining conceptual and ontological inconsistencies as discussed in the following sections. Individuals of rhetorical figures that are not part of the Ploke Ontology remain untouched. These individuals can be used as placeholders for future extension of potential ontologies in the rhetorical figure domain.

5.2.3 Conceptual Inconsistency

Conceptual inconsistency is a combination of conceptual heterogeneity and terminological heterogeneity [66]. It is caused by differences in definitions of rhetorical figures and the scopes of the ontologies. Conceptual inconsistency can be terminological or due to differences in coverage.

Terminological Inconsistency

Terminological inconsistencies occur when different names are used for the same rhetorical figures, or when a rhetorical figure is represented as different entities. For example, epizeuxis is defined as a figure in which *words or word groups are repeated immediately* in the Ploke Ontology, but defined as a figure in which *words or word groups are repeated three or more times* in GRhOOT.

In order to resolve terminological inconsistencies, the definitions will be carefully compared. In the case of epizeuxis as mentioned above, Wang et al. [220] first distinguishes representations of epizeuxis in the ontologies by creating a class **EpizeuxisG** for **epizeuxis** in GRhOOT. The class **Epizeuxis** follows the definition in Figure 5.1 in the Ploke Ontology.

Figure 5.2 demonstrates how **epiz1**, an instance of **Epizeuxis**, is represented graphically using the phrase *long, long ago*. Recall that **epiz1** is connected to **immediateRep1**, an

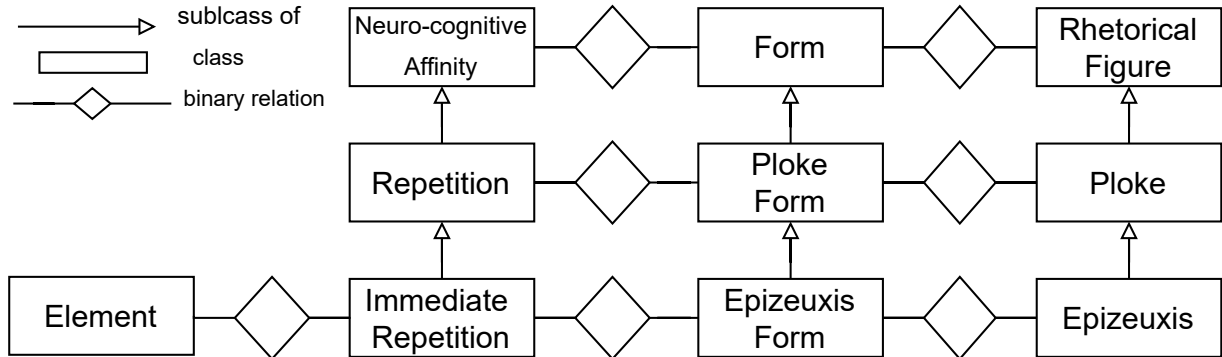


Figure 5.1: Classes related to **Epizeuxis** in the Ploke Ontology.

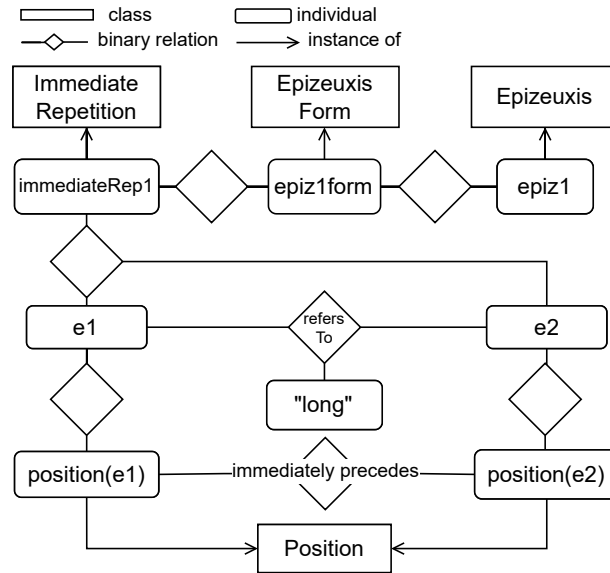


Figure 5.2: An instance of **Epizeuxis** in the Ploke Ontology of the phrase **long, long ago**. Adopted from Wang et al. [220].

instance of **ImmediateRepetition**, which is connected to two instances of **Element**, **e1** and **e2**. The **Element** class represents each occurrence of the repeated word or word group. An instance of **Element** refers to an instance of the class **Word/WordGroup** and is connected to an instance of the class **Position**. The position of the first element of **long**, i.e., **e1**, immediately precedes the second element, i.e., **e2**. Both **e1** and **e2** refer to the word **long**. Implicitly, the position of **e2** immediately follows the position of **e1**. There are two cases

to consider for the definition of **EpizeuxisG**:

1. Words or word groups repeat 3 or more times.
2. Words or word groups repeat 3 or more times. immediately, e.g., **a long, long, long time ago**.

In case 1, **EpizeuxisG** is not necessarily an epizeuxis, it is a subclass of **Ploke** distinguished from **Epizeuxis**. A new class **Ploke_3** is created as a subclass of **Ploke** with additional cardinality constraints on number of occurrences associated with the corresponding subclass of **Repetition**. In case 2, **EpizeuxisG** is a more specified version of both the class **Ploke_3** and **Epizeuxis**, therefore a subclass of both. The resulting classes and relations are shown in Figure 5.3.

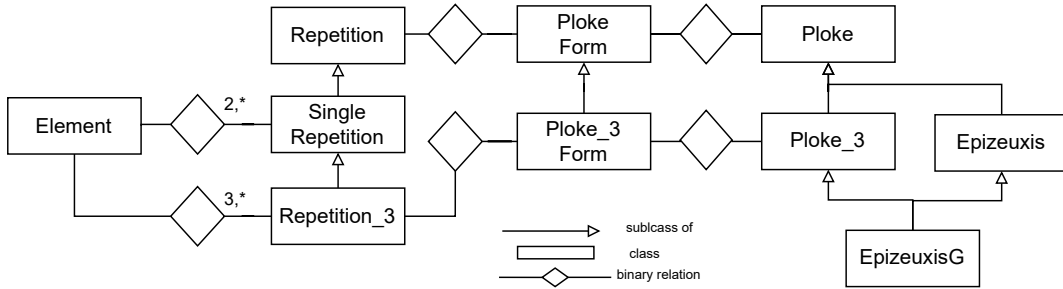


Figure 5.3: New classes **Ploke_3** and **EpizeuxisG** added to resolve Case 1 and 2 respectively. Adopted from Wang et al. [220].

Another example of terminological inconsistency regards the figure epanalepsis. Its corresponding Serbian term is *okruzivanje*, but in German the name is epanadiplose, whereas an epanalepse in German is just a repetition of words without any constraints, similar to *conduplicatio* in English. Two classes, **EpanadiploseG** and **EpanalepseG**, were created to represent epanadiplose and epanalepse defined in GRhOOT respectively. **Conduplicatio** and **Epanalepsis** are already subclasses of the class **Ploke** in the Ploke Ontology as shown in Figure 4.5. Therefore, the following mappings from GRhOOT to the Ploke Ontology regarding epanalepsis can be constructed: 1) **EpanadiploseG** → **Epanalepsis**; 2) **EpanalepseG** → **Conduplicatio**.

Inconsistency in Coverage

Different sets of rhetorical figures are included in each ontology due to *difference in coverage and perspective* [66]. In order to resolve coverage inconsistencies, each disjoint figure listed

in Table 5.2 will be checked individually. Since the Ploke Ontology has the most specific details, it is used as baseline ontology. Wang et al. [220] checks whether the figures from GRhOOT can fit into the model of the Ploke Ontology. For example, since mesodiplosis is the only figure that is only present in the Ploke Ontology and as this ontology serves as baseline, thus no further actions need to be taken for mesodiplosis.

On the other hand, there are three figures included in the Serbian RetFig and GRhOOT but not in the Ploke Ontology, i.e., antiklimax, anaklaza, and *emphase*. Antiklimax, an inversed version of the figure climax, is not considered as a figure of perfect lexical repetition in the Ploke Ontology. Recall from Chapter 2, climax is a figure that consists of anadiplosis and gradatio but also incrementum which is not a figure of perfect lexical repetition [181, 23]. Therefore, the Ploke Ontology includes only classes **Anadiplosis** and **Gradatio** as subclasses of **Ploke**, but no class to represent incrementum nor climax. Anaklaza and emphase are figures of perfect lexical repetition that are not represented in the Ploke Ontology which will be discussed in the following subsection.

5.2.4 Ontological Inconsistency

This type of inconsistency deals with domain-specific concepts that are represented differently in each ontology due to the different purposes and scopes when modeling the ontologies. This is referred to as semiotic or pragmatic heterogeneity [66]. A significant ontological inconsistency is how repetition is represented in each ontology. In the Serbian RetFig and GRhOOT ontologies, **repetition** is merely implicitly defined as object properties. Four different subproperties of the **repetition** property are differentiated here: **repetition of another form**, **repetition of the same form**, **repetition with different meaning**, **repetition of different kind**. Individual elements like **word**, **sentence**, or **phrase** can be assigned to those properties. In the Ploke Ontology, repetition is represented as a subclass of **NeurocognitiveAffinity** as demonstrated in Figure 5.2. It includes more details such as subclasses to represent different types of **Repetition**, the class **Element** to represent occurrences of repeated words or word groups, and their positions. Therefore, the ontologies are merged based on the Ploke Ontology while incorporating any suitable axioms from GRhOOT regarding a specific rhetorical figure of perfect lexical repetition. Epizeuxis is used again as an example for demonstration. In GRhOOT, an individual **Epizeuxis** is defined with the axioms in Table 5.3, where all values are individuals. Repetition and position orientation of epizeuxis are only implicitly defined with the object properties **isARepeatableElementOfTheSameForm** and **isInPosition**.

As shown in Figure 5.2, the Ploke Ontology defines repetition with an explicit and more detailed definition such as each occurrence of the repeated words or word groups. A

Object Property	Value
isARepeatableElement OfTheSameForm	Wordelement
isInObject	Wordobject
isInPosition	Whole-Successive
isLinguisticGroup	Syntactic
isRhetoricalGroup	FigureOfSpeech
isInArea	Sentence
isInArea	Verse

Table 5.3: Axioms of Epizeuxis in GRhOOT. Adopted from Wang et al. [220].

class **ImmediateRepetition**, a subclass of **Repetition**, is used to represent the specific type of repetition triggered by the form of an epizeuxis represented by an **EpizeuxisForm** class. The positions of the repeated words or word groups are also defined with a **Position** class. An object property **immediatelyPrecedes**, which is a subproperty of **precedes** (similarly for **immediatelyFollows** and **follows**) represents the orientation of positions explicitly.

Another example of ontological inconsistency is the rhetorical figure *emphasis* in GRhOOT. It is defined as *emphasis of a word, often acoustically or with exclamation mark* [20]. It deals with phonological or orthographic methods of applying an emphasis effect. In the case of plope, the emphasis effect naturally applies to every plope since the repeated words or word groups would already increase, to some extent, the salience of the concept carried as part of the attentional effect [99], thus emphasizing the concept of the repeated word or word group. The Plope Ontology implicitly represents this emphasis effect as part of the neurocognitive path (the highlighted path in Figure 4.1). That is, the form of a rhetorical figure triggers neurocognitive affinities (e.g., repetition) which generate attentional and mnemonic effect (e.g., salience). Since the Plope Ontology does not deal with phonological, orthographic, or punctuation aspects of natural language, it does not include *emphasis* as part of its representation. This also suggests that the figure *anaklaza* is equivalent to *conduplicatio* under this representation, since the only difference between the definitions is the notion of ‘emphasis’ as shown in Table 5.1.

The next chapter presents an empirical experiment that demonstrates the attentional effects caused by plope figures during a conversation in the setting of a requirements elicitation interview.

Chapter 6

An Empirical Experiment of Ploke in Requirements Elicitation Interviews

6.1 Experiment

In a general RE setting, an analyst interviews a customer to elicit the customer's requirements, to be specified in an RS by the analyst.

I wanted to determine whether an analyst's use of pokes, i.e., anadiplosis, epanalepsis, and mesodiplosis, during a requirements elicitation interview

- increases the level of detail with which the customer expresses his/her requirements,
- leaves the customer with a favorable impression of the analyst, and
- makes what the analyst said in the interview memorable to the customer.

To do this determination, it will be necessary to *measure*

- levels of detail,
- favorability of impressions, and
- memorability of interviews,

or at least, the *difference* between pairs of the same.

While there is no absolute measure of the level of detail of a statement of a requirement, it is fairly straightforward to compare the levels of detail of two statements of a requirement, in order to say which statement of the requirement is more detailed.

The difference between the level of detail of the statement about a requirement, expressed before a requirements elicitation interview and the level of detail of the statement about the (same) requirement expressed after the requirements elicitation interview is called “the change in the level of detail of the statement about the requirement across the requirements elicitation interview”. This change is positive if the level of detail after the interview is more than the level of detail before the interview. The customer can be asked for his/her favorability of impressions of the analyst in terms of naturalness, engagement, efficiency, clarity, and friendliness. The memorability of a statement to a customer can be tested by seeing if the statement is listed among what the customer remembers about the interview.

In addition, I wanted to explore for the future, the use of an AI agent to conduct requirements elicitation interviews. In this imagined future RE setting, a human analyst is replaced by an AI agent that plays the analyst’s role in requirements elicitation interviews with a customer. The human analyst still writes the RS from the requirements elicited by the AI agent.

6.1.1 Research Questions and Hypotheses

In the imagined future setting with AI agent analysts’ interacting with customers, the research question to be answered is:

RQ: Does an AI agent analyst’s use of pokes, during a requirements elicitation interview, affect

- the change across the requirements elicitation interview in the levels of detail of the statements about the requirements elicited from the customer,
- the customer’s favorability of impressions of the AI agent analyst, and
- the memorability of the statements made by the AI agent analyst during the interview.

If I were studying a human analyst rather than an AI agent analyst, I would be considering human rhetorical expressive features such as gestures, facial expressions, tone,

and emotions. These features would affect a customer’s and an analyst’s favorability of impressions of each other. As an AI agent interacts strictly with text, these features are ignored in order to study the effects of rhetorical figures generated only by text.

Before I would attempt to build an actual AI agent, I want to use the outcome of this study to determine if an AI will work as envisioned. If the outcome of this study shows that the AI agent does not function as hoped, then it is not worth building the AI agent. Consequently, I personally simulate the AI agent’s interaction with a customer, by following in a chatbox carefully designed textual scripts that implement a tree of possible interactions with the customer.

In any experiment to answer the research question in the imagined future RE setting, it will be necessary for the AI agent to act in two different modes during requirements elicitation interviews,

1. Mode $\mathcal{R}$, in which the AI agent’s interview script uses rhetorical language that contains all of three specific kinds of pokes, and
2. Mode $\mathcal{P}$, in which the AI agent’s interview script uses plain language that contains none of the pokes.

Rhetorical figures used in this experiment are limited to only the three aforementioned pokes, i.e., anadiplosis, epanalepsis, and mesodiplosis. Recall that rhetorical figures are ubiquitous. Thus, there does not really exist a plain language. In this chapter, the term “plain language” means sentences using none of these three specific pokes.

This RQ suggests three null hypotheses to be tested.

- H1:** The changes in the levels of detail of the statements about requirements elicited from customers across $\mathcal{P}$ mode requirements elicitation interviews is the same as the changes in the levels of detail of the statements about requirements elicited from customers across $\mathcal{R}$ mode requirements elicitation interviews.
- H2:** The favorability of the customers’ impressions towards the AI agent analyst in $\mathcal{P}$ mode requirements elicitation interviews is the same as the favorability of the customers’ impressions towards the AI agent analyst in $\mathcal{R}$ mode requirements elicitation interviews.
- H3:** The memorability of the statements made by the AI agent analyst during $\mathcal{P}$ mode requirements elicitation interviews is the same as the memorability of the statements made by the AI agent analyst during $\mathcal{R}$ mode requirements elicitation interviews.

The rest of this section describes the design and procedure of an experiment to test the hypotheses.

A pilot study was conducted to allow refining the design and the procedure to what is described in this section. Information about and the materials used in the pilot study can be found in Appendix [D](#).

6.1.2 Plan and Method

This experiment was conducted using a between-subject design with two condition levels. Each participant answered two questionnaires and participated in a role-playing interview. The plot of the role-playing interview was that a customer meets with an AI agent that is programmed to behave like an analyst, in order for the AI agent to elicit requirements for the system that the customer has in mind.

Each participant played the role of the customer. To prepare for this role, the participant was given a short general description of the educational software system that the customer has in mind. The participant was told to fill in the details from his/her imagination. Thus, creativity was encouraged on the participant's part. No participant was told of the goal of this study ahead of time, in order not to affect the results and to ensure that the participant communicates with the AI agent in the most natural way possible.

The AI agent was simulated by a chatbot operated, unseen by any participant, by me, the experimenter, who carefully followed a pre-written script with a list of questions arranged in a response-driven flowgraph, in order to mimic an automaton. Thus, the interview was conducted in a Wizard of Oz manner. True to the nature of a simulated AI agent, the experimenter did not respond to any question that was initiated by any participant.

Thus, I imagined that an AI agent already exists that is capable of eliciting requirement specifications from a customer, during an interview with the customer, similar to the way a human analyst would during requirements elicitation. For example, I assumed that the AI agent is robust in recognizing and responding to a customer's utterances that fall in the tree of possible interactions. The study of rhetorical figures facilitates the design of current and future AI systems that involve rhetorical natural language to make the interpretation more natural. In the case of requirements elicitation, the effect is yet to be studied, even without the involvement of AI agents. On the other hand, AI systems with the ability to recognize certain rhetorical figures have been studied for decades [[17](#), [58](#), [194](#)]. Although, an application to elicit requirements has yet to materialize, the primary goal of this experiment is to demonstrate empirically the connection between neurocognitive

affinities and attentional effects as shown by the neurocognitive path of a rhetorical figure in Chapter 3, which is to be modeled computationally in future. A secondary goal of this experiment is to evaluate whether it is worthwhile to develop such an AI system to elicit requirements. A true AI system for this purpose will not be worth the considerable effort to build if even a simulated AI system cannot do what is needed.

For the purpose of this experiment, three of plokcs were chosen to use in constructing the AI agent’s scripts. The plokcs used are anadiplosis, epanalepsis, and mesodiplosis. Their definitions and examples are listed in Section 6.1.2.

Process

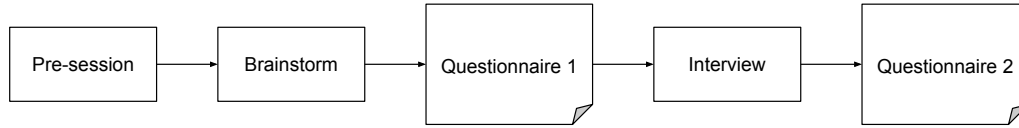


Figure 6.1: Experiment process.

Figure 6.1 shows the experiment process. There are five phases in the experiment. Every phase of the experiment was conducted online using Zoom, Google Forms and Google Chat (formerly known as Google Hangouts) due to the COVID-19 pandemic. The materials used for each phase are provided in Section 6.1.2. Each phase is described below:

Pre-session

I conducted a pre-session with each participant, in which each participant was provided with minimal instructions for the procedure of the study verbally. I stated that the job of the AI agent was to elicit the requirements of the system by asking the participant some questions. I informed the participant that the interview will be recorded as screenshots with all personal information removed. I kept the screenshots of the conversation as a reference for comparing the elicitation session with the same participant’s answered questionnaires. I did not question or guide the participant regarding his/her ideas on the system during this phase of the study. At the end of the pre-session phase, I sent a link that points to a form that contains an overall description of the experiment and materials of the Brainstorming and Questionnaire 1 phases. I created the form using Google Forms.

Brainstorming

Before any participant’s interview began, he/she was given a general description of the system that the customer has in mind, and was asked to brainstorm privately for ideas within the scope of the description. The ideas were recorded by responding to questions in Questionnaire 1.

Questionnaire 1

After the brainstorming phase, I asked the participant to complete Questionnaire 1. The questionnaire asked the participant to describe the software in terms each of purpose, users, and most important features, using at most three short phrases, each of which can be as short as a single word. The limit on the number of short phrases was to prevent participants from writing long articles about their software ideas. Thus, the responses can be easily compared for consistency with those of the same participant’s responses of Questionnaire 2, to be answered after the interview. Responses of Questionnaire 1 were downloaded from Google Forms and stored as “.csv” files.

Interview

The participant and the AI agent conducted an interview. During the interview, the AI agent followed one of the two predefined scripts, for Modes $\mathcal{P}$ and $\mathcal{R}$, to interact with the participant. The mode of the agent was randomly assigned for each participant while having an equal number of participants in both modes. The AI agent was represented by a chatbot implemented using the Google Chat web application. The agent asked questions about the software and waited for the response from the participant before proposing the next question. Since the interview was considered to be a role-playing interview, it was expected that the participant would respond with content relevant to the software. Each interview took approximately 10–15 minutes. The conversation history between the AI agent and the participant was saved as screenshots with personal information such as username and profile pictures removed for the participants. Figure 6.2 shows a screenshot of the Google Chat messaging interface while a participant was chatting with the Mode $\mathcal{R}$ agent.

Questionnaire 2

After the interview, I asked the participant to complete Questionnaire 2. Questionnaire 2 first repeated the three questions of Questionnaire 1. Then, Questionnaire 2 asked two additional questions, to evaluate:

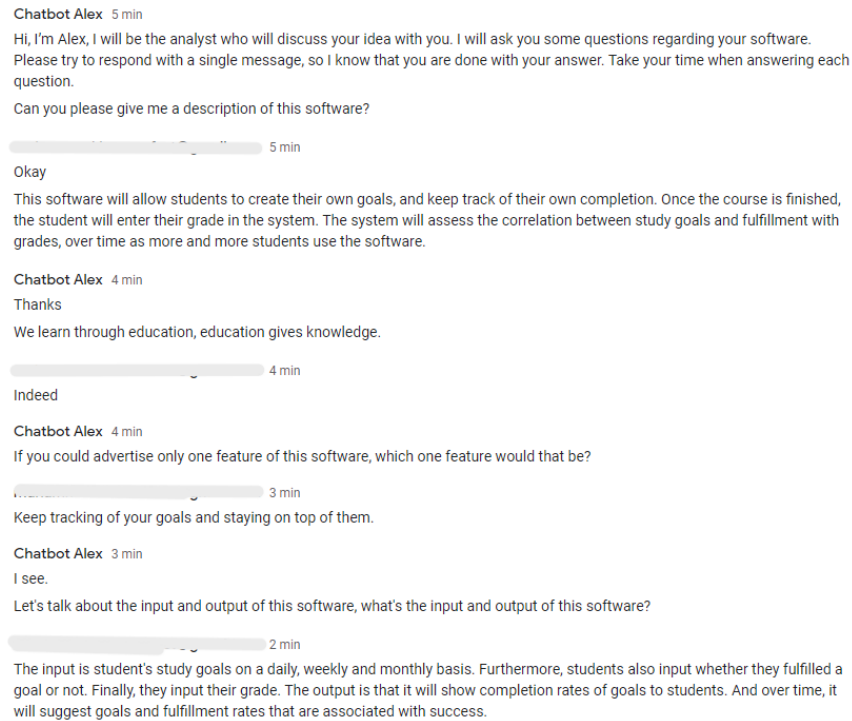


Figure 6.2: Screenshot of a Mode $\mathcal{R}$ conversation.

1. the participant's favorability of impressions towards the AI agent by asking his/her impression in terms of naturalness, engagement, efficiency, clarity, and friendliness, and
2. the memorability of the statements or questions delivered by the AI agent during the interview, by asking whether the participant could remember any statement made by the AI agent.

Responses of Questionnaire 1 were downloaded from Google Forms and stored as ".csv" files.

Materials

This section presents the materials used in the experiment such as the software description, questionnaires, and the interview scripts that were presented to the participants during the study.

Overall Description: Participants accessed the questionnaires via Google Forms. The following overall summary of the experiment appears at the top of Questionnaire 1.

This study consists of two questionnaires and a role-playing interview. You are asked to play the role of a customer who has an idea for a software and is having an interview with a software development company to discuss your idea. The software development company is fully automated, so instead of an in-person interview, the company has built a chatbot that is able to discuss your idea with you. A general description of the software is provided below.

Software Description:

The software description that was provided to each participant is shown below. Each participant used approximately 5 minutes, to brainstorm privately about the software before his/her interview began privately.

You have an idea for software that tracks and evaluates a student's progress and performance in undergraduate level courses.

Questionnaires

As described previously, each participant answered Questionnaire 1 before and Questionnaire 2 after his/her interview. Both Questionnaires 1 and 2 asked the same first three questions:

1. Please describe the purpose of this software.
2. Please describe the targeted user groups of this software. Please be as specific as possible.
3. Please list the top 3 features of this software.

Questionnaire 2 has two extra questions:

4. Please rate the conversation experience you had with the analyst (1 = highly disagree, 5 = highly agree).
 - The conversation felt natural
 - The agent was exciting to me

- The interview was efficient and productive
 - The agent was clear with its statements
 - The agent was friendly when talking to me
5. Please recite/rephrase a line that you can remember from the agent.

The screenshot shows a digital questionnaire interface. At the top, a purple header bar contains the text "Section 2 of 6". Below this, the first question is labeled "Q1" with a close icon and a menu icon to its right. Underneath "Q1" is the text "Description (optional)". The question itself is "1. Please describe the purpose of this software." followed by the instruction "Please use at most 3 short phrases to complete this question". Below the question are three separate input boxes for short answers, each labeled "Q1 Phrase 1:", "Q1 Phrase 2:", and "Q1 Phrase 3:" respectively. Each input box contains the placeholder text "Short answer text" and a horizontal line for typing.

Figure 6.3: Questionnaires used in study

Interview Script

I wrote a detailed interview script for each mode as part of the experimental design. The interview scripts in both modes followed the same structure. The interview scripts are shown below with each line numbered. There were four questions, i.e., on Lines 2, 5, 7, and 8 in each interview script. The phrasing of the questions on Lines 5, 7, and 8 in Mode $\mathcal{P}$ was different from that in Mode $\mathcal{R}$. The script in Mode $\mathcal{R}$ incorporated mesodiplosis in Lines 5 and 7 and epanalepsis in Line 8. The repeated words and phrases are underlined

in Mode $\mathcal{R}$ script. For example, Line 8 repeats the word **users** in Mode $\mathcal{R}$ script which incorporates the figure epanalepsis. The concept of **users** was emphasized by repeating the term in the question. These questions were general and aimed towards high-level software requirement specifications. Thus, they are likely to be included in a real-world requirements elicitation interview.

The statement on Line 4 in Mode $\mathcal{P}$, **Education software is very important**, was written as **We learn through education, education gives knowledge** in Mode $\mathcal{R}$. The latter statement contains the figure anadiplosis which consists of repetitions of words at the end and beginning of a clause. This is also the only statement that emphasizes the importance of education. This chapter refers to this statement as the *statement of education*. The null hypothesis $H3$ partially tests whether there is a distinction between how likely the participants can remember information conveyed by this statement in both modes.

In each mode, the agent begins with the paragraph **Hi, I'm Alex, I will be the analyst who will discuss your idea with you ...** (Line 1) and ends with **Thank you for your time. That's all the questions I have** (Line 9). Connectives such as **Thanks** (Line 3) and **I see** (Line 6) were also used but appeared in the same order in both modes.

The definitions of the three plok figures, i.e., anadiplosis, epanalepsis, and mesodiplosis, are copied over from Chapter 3 for reader's convenience. The line numbers indicate the corresponding lines in the in Mode $\mathcal{R}$ script. The repeated words and phrases are underlined in Mode $\mathcal{R}$ script.

Anadiplosis: the repetition of a lexeme or lexical group on either side of a clause or phrase boundary, e.g., Line 4.

Mesodiplosis: the occurrence of the same lexeme or lexical group in the middle of proximal clauses or phrases, e.g., Lines 5, 7.

Epanalepsis: lexical repetition at the beginning and ending of a phrase or clause, e.g., Line 8.

Mode $\mathcal{P}$ Script:

1. Hi, I'm Alex,
 I will be the analyst who will discuss your idea with you.
 I will ask you some questions regarding your software.
 Please try to respond with a single message,

so I know that you are done with your answer.
Take your time when answering each question.

2. Can you please give me a description of this software?
3. Thanks
4. Educational software is important.
5. What do you think is the most important feature of this software?
6. I see.
7. What's the input and output of this software?
8. Who will be the targeted user of this software?
9. Thank you for your time. That's all the questions I have.

Mode $\mathcal{R}$ Script:

1. Hi, I'm Alex,
I will be the analyst who will discuss your idea with you.
I will ask you some questions regarding your software.
Please try to respond with a single message,
so I know that you are done with your answer.
Take your time when answering each question.
2. Can you please give me a description of this software?
3. Thanks.
4. We learn through education, education gives knowledge.
5. If you could advertise only one feature of this software,
which one feature would that be?
6. I see.
7. Let's talk about the input and output of this software,
what's the input and output of this software?
8. The users, who will be the targeted users?
9. Thank you for your time. That's all the questions I have.

Participants

There were 50 participants and each of the participants was an undergraduate or a graduate student at the University of Waterloo. Each participant was randomly assigned either Mode $\mathcal{P}$ or Mode $\mathcal{R}$ before conducting the experiment, to end up with 25 participants in each mode. Each participant used Zoom to participate in the experiment with the experimenter. The web application Google Chat was used during the interview session with the agent. The experimenter’s camera and microphone were turned off throughout the experiment except for the pre-session, in between sessions, and when a participant had a question. The questionnaires were distributed using Google Forms. All phases of the experiment were conducted on the participant’s own device, which was a laptop or a desktop for all participants but one who used a mobile phone.

6.2 Evaluation Method and Analysis

The goal of the analysis of the data gathered from the experiment is to determine the *distinction* between Modes $\mathcal{P}$ and $\mathcal{R}$, as shown by the data gathered in the experiments comparing Modes $\mathcal{P}$ and $\mathcal{R}$.

6.2.1 Data

The data collected are in the form of textual responses to each question in Questionnaires 1 and 2. The questions are listed in 6.1.2 under the heading “Questionnaires”. The answers to Questions 1, 2, 3, and 5 are qualitative data consisting of free-form textual answers. The answers to Question 4 are quantitative data consisting of 5 Likert Scale values, each from 1 through 5.

6.2.2 Question 1–3

The goal of the analysis of the data gathered from Questions 1 to 3 of Questionnaires 1 and 2 is to determine the *distinction* between Modes $\mathcal{P}$ and $\mathcal{R}$ in terms of levels of detail.

Subjects, Questionnaires, Questions, and Phrases

The set of participants, $\mathcal{P}_1, \dots, \mathcal{P}_s$, that did the experiment in Mode $\mathcal{P}$ is disjoint from, but is the same size, $s = 25$, as the set of participants, $\mathcal{R}_1, \dots, \mathcal{R}_s$, that did the experiment

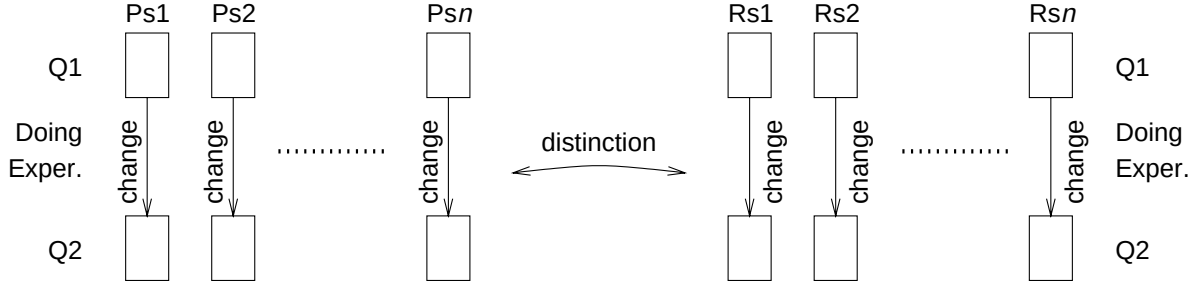


Figure 6.4: Visualization of Terms

in Mode $\mathcal{R}$. Figure 6.1 shows that each participant in either mode filled out Questionnaire 1 (Q1) before starting the experiment, and later, after finishing the experiment, filled out Questionnaire 2 (Q2). Q2 has the same initial three questions as Q1 and then two additional questions.

Question 1 ($q1$) of both Q1 and Q2 asks about the SW’s purposes.

Question 2 ($q2$) of both Q1 and Q2 asks about the SW’s users.

Question 3 ($q3$) of both Q1 and Q2 asks about the SW’s features.

Question 4 ($q4$) of only Q2 asks to rate with a 5-point Likert Scale value the conversation with the agent by five qualities of a good conversation.

Question 5 ($q5$) of only Q2 asks to recite or rephrase a memorable line from the agent.

The answer to any of $q1$, $q2$, and $q3$ consists of at most three phrases, ϕ_1 , ϕ_2 , and ϕ_3 , each of which can be a natural language sentence in English. In the rest of this chapter, Question j in Questionnaire i , i.e., qj in Qi , is called “ $Qiqj$ ”, and Phrase k in Question j in Questionnaire i , i.e., ϕ_k in qj in Qi , is called “ $Qiqj\phi_k$ ” and is called “ $Qi\phi_k$ ” when the context is restricted to a single question qj or when the question does not matter.

Terminology and Metrics

For any participant π , π ’s *change from Q1 to Q2* is the difference between

π ’s answers to $q1$, $q2$, and $q3$ in Q1

and

π ’s answers to the same questions in Q2.

For each mode, m , m ’s *change from Q1 to Q2* is an aggregation, to be described later, of π ’s change from Q1 to Q2 for all participants, π , that did the experiment in m .

The *distinction* between Mode $\mathcal{P}$ and Mode $\mathcal{R}$ is the difference between Mode $\mathcal{P}$'s change from Q1 to Q2 and Mode $\mathcal{R}$'s change from Q1 to Q2.

Thus, change is a time-ordered, asymmetric difference, while distinction is a time-independent, symmetric difference. That is, for any participant π , π 's change from Q1 to Q2 is different from, and is the opposite or negative of, π 's change from Q2 to Q1, while the distinction between Mode $\mathcal{P}$ and Mode $\mathcal{R}$ is the same as the distinction between Mode $\mathcal{R}$ and Mode $\mathcal{P}$.

To make the description of the analysis of the phrases of the answers to any question independent of the topic of the question, the word “PUF” is introduced to stand for any topic. A *PUF* is either

- a single purpose (P),
- a single user (U), or
- a single feature (F).

A phrase in a participant's answer to a question in Q1 to Q2 should be about at least one topic, i.e., about one PUF. Any PUF is described at some level of detail, ranging from mere naming to full detail. The two levels that are distinguished are (1) merely naming and (2) giving any more detail than merely naming. Thus, any phrase giving any more detail about a PUF than merely naming the PUF, also implicitly names the PUF.

The measures are defined. Let π be a participant.

- π 's change for qn from Q1 to Q2 is “N”
if and only if
 - the at most 3 phrases of π 's answer for qn in Q2
 - merely name at least 2 more PUFs of qn 's topic than do
 - the at most 3 phrases of π 's answer for qn in Q1.
 (i.e., merely name at least 2 more purposes, at least 2 more users, or at least 2 more features)
- π 's change for qn from Q1 to Q2 is “SN”
if and only if
 - the at most 3 phrases of π 's answer for qn in Q2
 - merely name exactly 1 more PUF of qn 's topic than do
 - the at most 3 phrases of π 's answer for qn in Q1.

- π 's change for qn from Q1 to Q2 is "D"
if and only if
 - the at most 3 phrases of π 's answer for qn in Q2
 - give at least 2 more details about PUFs of qn 's topic than do
 - the at most 3 phrases of π 's answer for qn in Q1, but
 - for exactly the same PUFs that are named
 - in π 's answer for qn in Q1.
- π 's change for qn from Q1 to Q2 is "SD"
if and only if
 - the at most 3 phrases of π 's answer for qn in Q2
 - give exactly 1 more detail about PUFs of qn 's topic than do
 - the at most 3 phrases of π 's answer for qn in Q1, but
 - for exactly the same PUFs that are named
 - in π 's answer for qn in Q1.
- Otherwise, π 's change for qn from Q1 to Q2 is "NC". This "otherwise" includes
 - that the at most 3 phrases of π 's answer for qn are the same in Q1 and Q2,
 - as well as that the changes went in the negative direction,
i.e., that π 's change for qn from Q2 to Q1 would be
"N", "SN", "D", or "SD".

NC (No change): The "NC" change includes the case of no change in naming, i.e., no addition of name of a PUF; and no details added. Since fatigue may affect a participant's response in Q2, I include decrease in details and removal of names of PUFs in the "NC" category instead of assigning independent categories. A negative change in Q2, i.e., names fewer PUFs and gives fewer details, does not indicate the interview has a negative impact. The responses in Q2 is not the final requirements elicited from the interview but an indication of change in thought of the participant. A participant could remove a feature because he/she now thinks that feature is redundant. The goal is to measure changes of a participant between his/her responses in Q1 and Q2 instead of the quality of the change, therefore it is reasonable to set "NC" as the lowest rating and consider only positive changes, i.e., "N", "SN", "D", and "SD". The change and distinction is what this experiment is after. Note that a participant may have carefully thought through his/her idea during the brainstorm and Q1 phase, therefore no change was made in Q2. This corresponds to the case in the real world in which a customer understands exactly the software requirement he/she is looking for. There is not much improvement can be made

during the requirements elicitation interview. Thus, a “NC” does not necessarily indicate a lower quality of response in Q2.

For each x & n , equal to one of “P” & 1, “U” & 2, and “F” & 3,

- π ’s $\Delta x = 0$, if and only if π ’s change for qn from Q1 to Q2 = “NC”,
- π ’s $\Delta x = 1$, if and only if π ’s change for qn from Q1 to Q2 = “SN” or “SD”, and
- π ’s $\Delta x = 2$, if and only if π ’s change for qn from Q1 to Q2 = “N” or “D”, and

π ’s change from Q1 to Q2 is the sum of π ’s Δ s for the three PUFs, i.e., the sum of

1. π ’s change, ΔP , for the SW’s purpose,
2. π ’s change, ΔU , for the SW’s users, and
3. π ’s change, ΔF , for the SW’s features.

That is, π ’s change from Q1 to Q2 = $\Delta P + \Delta U + \Delta F$.

For each mode, m , m ’s change from Q1 to Q2 is the arithmetic mean of the changes from Q1 to Q2 of all n of m ’s participants, where n is the common number of participants in the two modes. That is,

$$m\text{'s change from Q1 to Q2} = \frac{\sum_{i=1}^n s_i\text{'s change from Q1 to Q2}}{n},$$

where s_i for $i = [1 \dots n]$ are m ’s n participants.

Evaluation Method

Originally, I intended that the responses in Q1 and Q2 would be compared question by question, i.e.,

- Q1q1 would be compared with Q2q1, about purposes,
- Q1q2 would be compared with Q2q2, about users, and
- Q1q3 would be compared with Q2q3, about features.

However, as I was coding the questionnaires, I noticed that an occasional phrase in an answer for a question about the topic of another question. If I did exactly as I intended, the change from Q1 to Q2 for a typical participant would be incorrect. So, I decided to first shuffle the 9 phrases of the answers for $q1$, $q2$, and $q3$ in a questionnaire so that each phrase is in the answer of the question for the phrase’s topic. Then I would do the intended comparison. In fact, this shuffling occurred 15 times for only 13 participants out of the 50 participants. In most cases, only 1–2 phrases needed to be shuffled in the responses

from these 13 participants. All of the shuffling was in phrases in $q1$ and $q3$, indicating ambiguity between $q1$, regarding purpose, and $q3$, regarding features. This ambiguity is discussed further in Section 6.5.

This decision creates the possibility that a given question could have as many as 9 phrases and as few as 0 phrases about its nominal topic and that the change for qi be “N” or “D” because $Q2qi$ ’s phrases merely name 9 more PUFs, or give 9 more details about PUFs of qi ’s topic than do $Q1qi$ ’s phrases. In fact, the maximum number of phrases attributed to any PUF was 5.

Evaluation Examples

The following examples demonstrate the evaluation process by an evaluator. A corresponding pair of phrases (ϕ_i, ϕ_j) consists of two phrases in which the phrase ϕ_i in Q1 and the phrase ϕ_j is in Q2, and both ϕ_i and ϕ_j are describing the same PUF by the same participant π . Note that a phrase may not have a corresponding phrase, i.e., $(\phi_i, _)$. In this case, a PUF mentioned in Q1 was discarded in Q2.

Example 1

Below is an example for a participant’s response for $q2$, which asks to describe the users of the software.

Questionnaire 1

ϕ_1 : faculty

ϕ_2 : students

ϕ_3 : university office administration

Questionnaire 2

ϕ_1 : students would consult their progress and use as motivation

ϕ_2 : faculty could target efforts to students that are in need of improving their progress

ϕ_3 : faculty can query trends in student data to make informed decisions and work in the efficiency of their teaching

Firstly, the evaluator attempts to investigate whether two or more phrases from Q1 and Q2 are describing the same type of user. In this case, each of $Q1\phi_1$, $Q2\phi_2$, and $Q2\phi_3$ is describing **faculty** while each of $Q1\phi_2$ and $Q2\phi_1$ is describing **student**. So the corresponding pairs are $(Q1\phi_1, Q2\phi_2)$, $(Q1\phi_1, Q2\phi_3)$, $(Q1\phi_2, Q2\phi_1)$, and $(Q1\phi_3, _)$. Each phrase in Q2 is giving more details than does **faculty** or **student** in Q1. The participant gave three more details about the users in the phrases in Q2 than the phrases in Q1. Therefore, the evaluator assigns “D” to the change of $q2$. Note that $Q1\phi_3$, **university office administration** is not mentioned in Q2. Therefore, the corresponding pair is $(Q1\phi_3, _)$, and it is assigned “NC”.

Example 2

Below is a participant’s responses for $q3$ in both questionnaires.

Questionnaire 1

ϕ_1 : study plan & guide

ϕ_2 : performance display

ϕ_3 : forum

Questionnaire 2

ϕ_1 : study plan assignment reminder

ϕ_2 : progress display bar

ϕ_3 : show quizzes

The evaluator identifies the corresponding pairs $(Q1\phi_1, Q2\phi_1)$, $(Q1\phi_2, Q2\phi_2)$, $(Q1\phi_3, _)$, and $(_, Q2\phi_3)$. For the pair $(Q1\phi_1, Q2\phi_1)$, the response to $q3$ in Q2 is more detailed than the response to the same question in Q1: **study plan assignment reminder** and **progress display bar**. For the pair $(Q1\phi_2, Q2\phi_2)$, the response in Q2 describes the same feature as, but is more detailed than **study plan & guide** and **performance display**, the response in Q1. The additional detail provides specific forms of the features study plan and performance display, i.e., a reminder and a display bar, respectively. However, **show quizzes** in the pair $(_, Q2\phi_3)$, the response by the participant to $q3$ in Q2, describes a feature that is different from that described by **forum** in the pair $(Q1\phi_3, _)$, the response by the same participant to the same question in Q1. Each of the pairs $(Q1\phi_1, Q2\phi_1)$ and

(Q1 ϕ_2 , Q2 ϕ_2) provides more details about F in Q2 than in Q1. The pair ($_$, Q2 ϕ_3) merely names exactly one more F in Q2 than in Q1. Since two more details were provided and only one more F was named, the evaluator assigns a “D” for this participant.

6.2.3 Question 4

The answers for q_4 are five 5-point Likert scale values. The change is evaluated by averaging the five values for naturalness, engagement, efficiency, clarity, and friendliness. These average scores were compared between Modes $\mathcal{P}$ and $\mathcal{R}$.

6.2.4 Question 5

The goal of q_5 is to determine if the use of the three pokes caused statements made by the AI agent to be more memorable than otherwise. The evaluator compares the answers to q_5 in Mode $\mathcal{P}$ Q2s and Mode $\mathcal{R}$ Q2s, and assigns one of the following categories to a response of a participant:

1. None: nothing stood out, including answers such as **I see, please give me a description**, etc.
2. Question: the participant described a question
3. Edu-describe: the participant described the statement of education
4. Edu-verbatim: the participant recited the statement of education verbatim

Each category is then assigned a score. A participant who mentions merely anything else such as **I see** or **Thanks** is assigned “None” and receives 0. A participant who mentions a question receives 1 point, whether verbatim or not. An emphasis was put on the statement on education, i.e., **Educational software is important**, and **We learn through education, education gives knowledge** since these are the only non-question sentences that deliver a takeaway message during the conversation. It is the only statement made regarding the theme of the software idea, i.e., education. A score of 2 was assigned to each response mentioning the statement of education, i.e., “Edu-describe”, in both modes. A participant in Mode $\mathcal{R}$ who is able to recite the statement about education verbatim receives 3 points. The assignment “Edu-describe” is exclusively for Mode $\mathcal{R}$. The assignment “Edu-describe” does not evaluate in favor of Mode $\mathcal{R}$ since the statement

is significantly shorter in length in Mode $\mathcal{P}$ comparing to the same statement in Mode $\mathcal{R}$. It is much easier to restate Line 4 in the Mode $\mathcal{P}$ script than in the Mode $\mathcal{R}$ script. Therefore, more points should be awarded for reciting the statement verbatim in Mode $\mathcal{R}$ to reflect the difference of difficulty to recite Line 4 in Mode $\mathcal{P}$ and Mode $\mathcal{R}$.

6.3 Results

This section reports the evaluated results of responses from Q1 and Q2 from participants in both Modes $\mathcal{P}$ and $\mathcal{R}$.

6.3.1 Datasets

Two evaluators evaluated the responses of $q1$ to $q3$, I and Berry, one of my supervisors. I evaluated the responses twice. Thus, the evaluators produced three individual datasets in total, i.e., W1, W2, by me and B1, by Berry. My two evaluations were completed more than 6 months apart. The Kappa interrater agreement values are reported in Table 6.1. The average of the three datasets are produced as another dataset AVE. The evaluators came to a consensus between W2 and B1 after a discussion for every evaluation on which they differed. This consensus evaluation is recorded as a separate dataset CON. The Kappa values between each pair of the datasets W1, W2, B1, and CON are reported in Table 6.1. Because the dataset CON was a consensus between datasets B1 and W2, the Kappa value between W1 and CON is lower than between either of W2 or B1 and CON.

Each dataset is split into sub-datasets for Modes $\mathcal{P}$ and $\mathcal{R}$ and these are named with suffix -P and -R respectively.

Separate datasets are not need for the responses to $q4$ since responses to $q4$ are quantitative. The evaluation of the responses to $q5$ is simply checking whether each response contains certain contents from an interview script.

6.3.2 Duration of Brainstorming and Prior Knowledge of the Software

I recorded the duration between the time that a participant received the description and Q1 and the time that the participant had started the conversation with the agent, i.e., the brainstorming time. The average brainstorm took 9 minutes and 40 seconds, with the

shortest being 7 minutes and longest being 13 minutes. Since the description of the software was given to a participant only at the beginning of the his/her session, the participant was unlikely to have thought about the software beforehand. To be certain, I asked each participant verbally if he/she had ever thought of similar ideas before. Every participant responded “No”.

6.3.3 Levels of Detail

Evaluation	W1	W2	B1	CON
W1	1	0.3375	0.3398	0.342
W2	-	1	0.3523	0.721
B1	-	-	1	0.53
CON	-	-	-	1

Table 6.1: Cohen’s Kappa among datasets

Evaluation	W	p value	Normal?
W1-P	0.9205	0.05255	Yes
W1-R	0.9264	0.07195	Yes
W2-P	0.9351	0.1139	Yes
W2-R	0.8477	0.001591	No
B1-P	0.9512	0.2664	Yes
B1-R	0.9215	0.05547	Yes
AVE-P	0.9538	0.3045	Yes
AVE-R	0.9237	0.06237	Yes
CON-P	0.9307	0.09039	Yes
CON-R	0.9066	0.02561	No

Table 6.2: Shapiro Wilk Test for responses of q1–q3

All datasets except for W2-R and CON-R are normally distributed as is shown in Table 6.2. Thus, the p values of the distinctions between Mode $\mathcal{P}$ and Mode $\mathcal{R}$ were calculated using a two-tailed Welch’s T-test, and the p values of the distinctions between W2-P and W2-R and between CON-P and CON-R were calculated using a two-tailed Mann Whitney U Test. A positive distinction value indicates that the change in Mode $\mathcal{P}$ is higher than the change in Mode $\mathcal{R}$. A negative distinction value indicates that the change in Mode $\mathcal{R}$ is higher than the change in Mode $\mathcal{P}$.

Evaluation	Change Mean	Change SD	Distinction	p value of Distinction
W1-P	2.24	1.5305	−0.36	0.4406
W1-R	2.6	1.673		
W2-P	3.48	1.3	0.24	0.5491
W2-R	3.24	1.422		
B1-P	2.92	1.547	0.56	0.2043
B1-R	2.36	1.466		
AVE-P	2.88	1.222	0.147	0.6776
AVE-R	2.733	1.207		
CON-P	3.4	1.2909	0.36	0.3757
CON-R	3.04	1.306		

Table 6.3: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$

For the AVE dataset, the distinction between

- the mean of the change in Mode $\mathcal{P}$, 2.88 ($SD = 1.222$), and
- the mean of the change in Mode $\mathcal{R}$, 2.733 ($SD = 1.207$)

is 0.147 with $p = 0.6776$.

For the CON dataset, the distinction between

- the mean of change in Mode $\mathcal{P}$, 3.4 ($SD = 1.2909$), and
- the mean of change in Mode $\mathcal{R}$, 3.04 ($SD = 1.306$)

is 0.36 with $p = 0.3757$.

The distinctions of the changes are not significant. Therefore, the null hypothesis $H1$ cannot be rejected.

Among individual datasets, only dataset W1 has a higher change value in Mode $\mathcal{R}$ than in Mode $\mathcal{P}$, giving a negative distinction value. However, none of the distinction measures between Modes $\mathcal{P}$ and $\mathcal{R}$ show significance. The results are shown in Table 6.3.

Evaluation	W	p value	Normal?
Naturalness-P	0.8566	0.002352	No
Naturalness-R	0.8831	0.008022	No
Engagement-P	0.8611	0.00288	No
Engagement-R	0.8081	0.0003118	No
Efficiency-P	0.7997	0.0002246	No
Efficiency-R	0.8658	0.003567	No
Clarity-P	0.5601	0.0000001547	No
Clarity-R	0.7331	0.000021	No
Friendliness-P	0.4922	0.00000003139	No
Friendliness-R	0.6087	0.0000005348	No
Total-P	0.9397	0.1454	Yes
Total-R	0.9559	0.3383	Yes

Table 6.4: Shapiro Wilk Test for q4 datasets

6.3.4 Favorability of Impressions

The data for each category in Table 6.4 are not normally distributed. Thus, the p values of the distinction between Mode $\mathcal{P}$ and Mode $\mathcal{R}$ were calculated using the two-tailed Mann Whitney U Test. Total-P and Total-R are the sum of the scores of all categories in Modes $\mathcal{P}$ and $\mathcal{R}$ respectively, and can be assumed normally distributed. I used the two-tailed Welch’s T-test to obtain the p value of the distinction between Total-P and Total-R. The results are reported in Table 6.5.

For the datasets Total-P and Total-R, the distinction between

- the mean of the scores in Mode $\mathcal{P}$, 20.56 ($SD = 3.3427$), and
- the mean of the scores in Mode $\mathcal{R}$, 20.4 ($SD = 2.5658$)

is 0.16 with $p = 0.8503$. The distinction is not significant. Therefore, the null hypothesis H_2 cannot be rejected.

Evaluation	Mean	<i>SD</i>	Distinction	<i>p</i> value of Distinction
Naturalness-P	3.88	1.053565	0.32	0.3526
Naturalness-R	3.56	1.193035		
Engagement-P	3.64	1.113553	−0.28	0.3593
Engagement-R	3.92	0.909212		
Efficiency-P	3.68	1.10755	−0.2	0.4774
Efficiency-R	3.88	0.927362		
Clarity-P	4.56	0.869866	0.16	0.2775
Clarity-R	4.4	0.816497		
Friendliness-P	4.8	0.408248	0.16	0.3526
Friendliness-R	4.64	0.4338		
Total-P	20.56	3.342654	0.16	0.8503
Total-R	20.4	2.565801		

Table 6.5: q4: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$

6.3.5 Memorability

The data for q5, shown in Table 6.6, are not normally distributed. Thus, I calculated the *p* value of the distinction between Mode $\mathcal{P}$ and Mode $\mathcal{R}$, using a two-tailed Mann Whitney U Test.

The distinction between

- the mean of score in Mode $\mathcal{P}$, 1 (*SD* = 0.707), and
- the mean of score in Mode $\mathcal{R}$, 1.44 (*SD* = 0.821)

is −0.44 with *p* = 0.08941. The distinction is not significant with a 95% confidence interval since *p* > 0.05. However, the distinction is significant with a 90% confidence interval since *p* < 0.1. Therefore, null hypothesis *H*3 can be rejected if the reduced confidence is acceptable.

Even though “Edu-verbatim” has a higher score and it can be assigned to responses in only Mode $\mathcal{R}$, it is also harder to achieve.

The frequency of each assigned category is reported in Table 6.8.

Evaluation	W	p value
q5-P	0.8082	0.0003123
q5-R	0.7391	0.00002566

Table 6.6: Shapiro Wilk test for the original q5 dataset

	Mode $\mathcal{P}$	Mode $\mathcal{R}$
M	1	1.44
SD	0.707107	0.820569
p value	0.08941	

Table 6.7: Distinction for q5

Evaluation	Mode $\mathcal{P}$	Mode $\mathcal{R}$
None	6	1
Question	13	16
Edu-describe	6	4
Edu-verbatim	-	4

Table 6.8: Count by category in Modes $\mathcal{P}$ and $\mathcal{R}$

6.4 Discussion

This section discusses the results reported in Section 6.3. In this section, $M_{\mathcal{P}}$ and $M_{\mathcal{R}}$ represent mean scores in Modes $\mathcal{P}$ and $\mathcal{R}$, respectively. $N_{\mathcal{P}}$ and $N_{\mathcal{R}}$ represent frequency values in Modes $\mathcal{P}$ and $\mathcal{R}$, respectively.

6.4.1 Levels of Detail

I expected that the responses provided for $q1$ through $q3$ would change after the interviews. In either mode, I expected that each participant would learn about the system under specification during the interview, leading, in either model to changes in his/her responses to $q1$ through $q3$. Moreover, in either mode, I expected that the responses provided by any participant for each of $q1$, $q2$, and $q3$ in Q2 be more detailed than the responses provided by the participant for the same questions in Q1. The issue concerning the distinction between Modes $\mathcal{P}$ and $\mathcal{R}$ is “In which mode is the change, if any, greater?” This distinction turns out to be too small to be significant ($p = 0.6776$ for dataset AVE, $p = 0.3757$ for dataset CON).

Therefore, $H1$ cannot be rejected, and the use of the specific pokes during requirements elicitation appears not to affect the response of a customer participating in the elicitation.

The question is “Why does there not appear to be a significant distinction between Modes $\mathcal{P}$ and $\mathcal{R}$?” One possibility is that there *is no* distinction. The other possibility is that there *is* a distinction, but by chance, the data failed to show the distinction that they should have, a Type II error. There are three factors that should be investigated as possible sources of a Type II error: the sample size, the interview script, and the evaluation method. Firstly, the sample size should certainly be increased. There were 25 participants in each mode and only 3 datasets were generated. An experiment with more participants and more datasets may show different results. Secondly, the interview scripts used in Mode $\mathcal{R}$ of this experiment includes three poke figures, anadiplosis, epanalepsis, and mesodiplosis. Each poke was used on its own and effort was made to eliminate other figures as much as possible¹. As discussed in Chapters 2 and 3, figure collocation is an important factor of the generation of attentional effects, because it is known that rhetorical figures are more powerful when they work together. I had decided to investigate the three pokes independently. In the case of this experiment, none of the three pokes used generated enough attentional effect on its own. Lastly, the method of evaluation has a great impact on the result. The evaluation method used in this experiment is definitely not the only method, and other evaluation methods could have generated different results.

6.4.2 Favorability of Impressions

Based on the results of $q4$ in Q2 for all participants, the Mode $\mathcal{R}$ agent scored higher in engagement and efficiency than did the Mode $\mathcal{P}$ agent. The Mode $\mathcal{P}$ agent scored higher than the Mode $\mathcal{R}$ agent in naturalness, clarity and friendliness. However, none of the distinctions are significant (minimum $p = 0.8503$). Once again, the sample size and interview scripts were factors that may have affected the result. The most significant distinction was found in the naturalness scores, in which the Mode $\mathcal{R}$ agent has an average score of only 3.56, while the Mode $\mathcal{P}$ agent has an average score of 3.88. Purposely adding repetitions in the Mode $\mathcal{R}$ may have decreased the feel of naturalness to participants during the conversation. In addition, sentences in Mode $\mathcal{P}$ are shorter than in Mode $\mathcal{R}$ since Mode $\mathcal{R}$ intentionally repeats certain words or phrases in a sentence. These shorter sentences may make the Mode $\mathcal{P}$ script appear more natural and clear.

To each agent, participants gave higher mean scores for clarity ($M_{\mathcal{P}} = 4.56$, $M_{\mathcal{R}} = 4.4$) and friendliness ($M_{\mathcal{P}} = 4.8$, $M_{\mathcal{R}} = 4.64$) than for naturalness, engagement, and efficiency.

¹This is hard to achieve since rhetorical figures are ubiquitous.

One participant mentioned that the question **The users, who are the target users of this software?** felt unfriendly. He said he felt like the agent was shaking his shoulders while shouting: “The users! Who are the users?”. However, it is a mystery to me why the participant considers this sentence unfriendly, and it will remain a mystery without an in-depth analysis and follow-up interview with the participant.

6.4.3 Memorability

The distinction between the answers for *q5* provided by participants in Mode $\mathcal{P}$ and Mode $\mathcal{R}$ is an indication of the salience and mnemonic effect of rhetorical figures discussed [106]. Chapter 3 explains how the concepts conveyed by sentences with such rhetorical figures become more recognizable and memorable among the interlocutors.

The mean score of *q5* in Mode $\mathcal{R}$ ($M_{\mathcal{R}} = 1.44$, $SD = 0.82$) is significantly higher than that in Mode $\mathcal{P}$ ($M_{\mathcal{P}} = 1$, $SD = 0.707$) with a 90% confidence interval ($p = 0.089$). More responses from participants in Mode $\mathcal{P}$ than in Mode $\mathcal{R}$ ($N_{\mathcal{P}} = 6$, $N_{\mathcal{R}} = 1$) were “None”. These responses included connective phrases such as **Thanks** and **I see** or the opening question **Can you please give a description of the software?** The participants in Mode $\mathcal{P}$ chose the most generic and standardized content that exists in both modes, indicating that these participants could not recall concepts mentioned in the questions or in the statement of education.

More participants in Mode $\mathcal{R}$ than in Mode $\mathcal{P}$ ($N_{\mathcal{P}} = 13$, $N_{\mathcal{R}} = 16$) responded to a question asked by the agent during the interview, indicating that participants in Mode $\mathcal{R}$ were more likely than those in Mode $\mathcal{P}$ to recall a question from the interview with the AI agent. Most importantly, more participants in Mode $\mathcal{R}$ than in Mode $\mathcal{P}$ ($N_{\mathcal{P}} = 6$, $N_{\mathcal{R}} = 8$) recalled contents from the statement of education, and half of these responses in Mode $\mathcal{R}$ were able to recite the statement of education verbatim despite that it is much longer than the statement in Mode $\mathcal{P}$. Thus, the use of pokes appears to have resulted in a more memorable conversation.

Recall that one of the goals of this experiment is to evaluate whether it is worthwhile to develop an AI system incorporating rhetorical figures for requirements elicitation. Although two out of the three null hypotheses cannot be rejected, rejecting $H3$ with 90% confidence interval is an indication that the use of pokes does affect the attention and perception of a customer towards certain concepts conveyed during a requirements elicitation interview. Being able to remember concepts conveyed in the questions and the statement of education is an indication that these concepts are more salient and memorable when conveyed using the three pokes. The connection between neurocognitive affinity and attentional effect

on the neurocognitive path of rhetorical figures is not yet modeled. The rejection of $H3$ serves as an empirical evidence that this connection indeed exists. Therefore, it is worth the effort to develop an AI system that is able to interpret knowledge and information regarding plokas.

As with the other conclusions, there is a chance of a Type II error due to factors such as the sample size, interview script, and the evaluation method. The next section discusses limitations and potential improvements of this experiment.

6.5 Limitations

A number of limitations of the experiment were mentioned in Section 6.4. More data is needed. In addition, experiment can be conducted with an improved design including modification of the questionnaires and the interview script, the choice of plokas and figure collocation embedded in the script. All are factors that may lead to a Type I or a Type II error. Also, deception and fatigue are limitations due to the experiment design. This section discusses these limitations in detail.

6.5.1 Data Sparsity

A limitation is the sparsity of the data collected in this experiment. There were 25 participants in each mode. The results would be more reliable and could possibly be different if more participants were involved. It is possible that the results have a Type II error and the null hypotheses $H1$ and $H2$ should have been rejected. Also a Type I error is possible such that $H3$ should not have been rejected. Involving more participants would reduce the likelihood of a Type I or Type II error.

6.5.2 Experiment Design

Questionnaire The design of $q1$ through $q3$ was not perfect. Section 6.2.2 mentions the ambiguity between purpose (P) and feature (F). Occasionally, the same PUF was mentioned multiple times in phrases across $q1$ and $q3$. Clearer definitions should have been provided or a different aspect of software requirements should be included in the questions $q1$ to $q3$ to avoid ambiguity.

Interview Script Repetition of words or phrases in Mode $\mathcal{R}$ will inevitably add unknown variables to the experiment process. Section 6.4.2 discusses the case of a participant’s complaint that the Mode $\mathcal{R}$ agent was unfriendly. Simply repeating the word **users** appears to have triggered the complaint from that participant. Rephrasing the question might neutralize the negative effect. Although I attempted to design a script that minimizes the difference between Modes $\mathcal{P}$ and $\mathcal{R}$ other than the repeated words or phrases, it is difficult to develop identical scripts in which the only difference is to repeat a word or phrase. An anadiplosis may be the most suitable ploy to achieve this task. For example, the question **Who will be the targeted user of this software?** may be asked in Mode $\mathcal{R}$ as **Who will be the targeted user, the user of this software?** However, participants may quickly notice the pattern if all questions are written with similar format. Noticing some pattern would make the repeated word more memorable, introducing some bias to the result.

The results of this experiment show that embedding the three plokies increases memorability of the statement of education despite that the statement in Mode $\mathcal{R}$ is longer. However, I believe that the distinction between Mode $\mathcal{P}$ and Mode $\mathcal{R}$ would be more significant if an effort were made to minimize the difference in length of each question or statement used in the scripts. That is, the length of each question or statement used in a script would still affect the memorability of the contents in the script. However, the effect should be small, since each question or statement in the scripts was relatively short in each mode. The question **If you could advertise only one feature of this software, which one feature would that be?** was the longest, with 18 words and 75 characters. I made an effort to reduce the difference in length for each question or statement. The statement of education has 4 words with 33 characters in Mode $\mathcal{P}$, i.e., **Educational software is important**, and 7 words with 52 characters in Mode $\mathcal{R}$, **We learn through education, education gives knowledge**. The words **learn** and **knowledge** may have affected the memorability of this statement. A possible improvement on the script is to replace the statement of education with **Educational software is important for knowledge** in Mode $\mathcal{P}$, which increases the length of this statement. This new statement of education mentions also the word **knowledge**. Thus, it has a closer match with the words used in the Mode $\mathcal{R}$ script.

Follow-up Discussion Due to time and resource limit, I did not include a formal follow-up discussion session with the participants. A follow-up discussion would retrieve more information on why did the participant respond to the questionnaires in the way did. Recall the case discussed in Section 6.4.2, a follow-up discussion with the participant would be beneficial to discover why the participant felt the Mode $\mathcal{R}$ agent was unfriendly to him.

6.5.3 Figure Collocation

Multiple pokes were included in the script of Mode $\mathcal{R}$. I attempted to avoid figure collocation by incorporating a single poke figure in each question or statement, in order to study the effects of the three pokes independently. Other schemes and tropes may appear in the interview scripts even if I try to limit the figure collocation in the Mode $\mathcal{R}$ script to pokes only. Thus, incorporating a single poke in each line of the Mode $\mathcal{R}$ script minimizes possible unknown variables such as the question: “which rhetorical figure generated the attentional effects?”. This experiment tested only three pokes, i.e., anadiplosis, epanalepsis, and mesodiplosis. However, each poke on its own may not be strong enough to affect the attentional effect. Other pokes such as antimetabole, epizeuxis, etc. can be included in future experiments and figure collocation can be considered. As mentioned earlier, figure collocation is an important phenomenon that has great impact on the generation of attentional effects such as salience, aesthetic pleasure and memorability. Including figures formed by multiple pokes such as [Example 2.1.1](#), *all for one, one for all*, may have an impact on the result.

6.5.4 Deception

Deception is inevitable due to the purpose of this experiment. Recall that the true goal of this experiment was not revealed to the participants during the entire experiment. Even though neither I nor the instructions said that the goal of this experiment was to test the robustness of the chatbot, and I did not say anything explicitly to mislead any participant, the participants were likely to believe that the goal of this study was to test the chatbot. It is unclear whether this deception would have impacted the participant’s response but it does not affect the result presented, since this impact would be equally likely to all participants in both Modes $\mathcal{P}$ and $\mathcal{R}$. The true goal of the experiment was revealed to the participants after the experiment. I did not consider deception while designing the experiment. I focused on minimizing the difference between Modes $\mathcal{P}$ and $\mathcal{R}$ other than the interview scripts. Therefore, any deception is unintentional.

6.5.5 Fatigue

As discussed in Section 6.2.2, I noticed fatigue in the responses of $q1$ through $q3$ of some participants. These participants tended to write less in Q2 due to the fact that they have already entered similar information twice, in Q1 and during the interview, before

responding to Q2. Some tended to write more general high level descriptions for Q2 than for Q1. The tendency of writing less may have resulted in a more concise description in the responses in Q2. Also, writing less works against providing more detail in Q2, which was the expected and hoped-for outcome. This tendency could have been caused by fatigue or having thought the software idea multiple times throughout the experiment, or a combination of both. For example, a participant wrote a more concise description of the users in Q2, e.g., `...More specifically, main target is schools and educational institutions` in Q1 was re-written as `Educational institutions` in Q2.

Although the instruction was `answer the questions again`, some participants were aware of what they wrote before and tended not to repeat. Some responses start with `[i]n addition to mentioned earlier ....` One participant said that he/she intentionally avoided writing the same PUFs in Q2 that he/she wrote in Q1, because he/she thought that was the requirement. In another case, the participant thought that his/her responses in Q2 must be the same as in Q1 for *q1*, *q2*, and *q3*. One participant mentioned that he/she had forgotten what he/she wrote in Q1. Participants were not given access Q1 while answering Q2 to prevent them from simply copying responses from Q1.

6.6 Future Work

This section discusses potential directions of future work that could further improve the experiment design and potential applications. The improvements include incorporating other rhetorical figures than pokes, analyzing the response time of each question or phase for all participants, developing a responsive AI agent that includes graphical and vocal features, involving a human analyst, and analyzing the connection between rhetorical figures and the final software requirements specifications.

6.6.1 Addressing Limitations

The limitations discussed in Section 6.5 should be fully addressed. A larger scaled experiment with a improved questionnaires and interview scripts that involves figure collocation should be conducted in the future. However, deception and fatigue are inevitable due to the nature of the design of this experiment.

6.6.2 Incorporating Other Rhetorical Figures

The same experiment design can be implemented to investigate the attentional effects of other types of rhetorical figures in a requirements elicitation interview. Other types of rhetorical figures can be included simply by modifying the interview scripts in Modes $\mathcal{P}$ and $\mathcal{R}$. The pilot study of this experiment included multiple types of figures including tropes and distinctions between Modes $\mathcal{P}$ and $\mathcal{R}$ were noticed. However, a conclusion cannot be made due to small sample size. Also, a similar experiment design can be implemented to investigate in processes other than requirements elicitation interviews and could be applied to domains other than RE.

6.6.3 Analyzing Response Time

An improvement of the experiment design would be to trace the cause of the difference in response time from the participants on each question asked by the agent. I noticed that the times taken to answer the questions were different both inter- (i.e., different participants on the same question) and intra-participant (i.e., same participant on different questions). A separate study is required with the participants to discover the reasons behind the difference in response times, which could be caused by various factors such as Internet delay, fatigue, loss of focus, or lack of fluency in the language. Also a personality test is required since some participants tend to think slowly and with many details when responding to any question, while others may respond faster and with fewer details. Also the duration for a participant to complete a phase in the experiment differed between participants. The difference in duration to complete each phase could also be investigated for potential findings.

6.6.4 A Talking Chatbot

This experiment focuses on plokas embedded in the text input. The design of this experiment is suitable for studying plokas, but the study of other figures using similar experiment design may benefit from a chatbot with voice features. In the case of plokas, a talking chatbot can be implemented in which the agent in Mode $\mathcal{R}$ repeats a word such as **feature** or **users** as if it stuttered. Other parts of the scripts will be identical for Modes $\mathcal{P}$ and $\mathcal{R}$. The goal is to investigate the attentional effect of a single conduplicatio, epizeuxis, or anadiplosis on the targeted terms. Such an experiment design is difficult to achieve through only text, e.g., **What are the features, the features of the software?**. The anadiplosis in this example, would be easily noticed if used multiple times during an interview that

uses only text. However, the anadiplosis, combined with a natural pause at the comma, is much more natural when delivered using voice. While incorporating a talking chatbot may introduce unknown variables related to voice such as tone, volume, etc, it will ensure that the scripts are identical except for the repeated word. However, this experiment design would test only a limited number of pokes such as anadiplosis or epizeuxis instead of a variety of poke figures. Although the scripts of the two modes cannot be identical, a carefully designed script may achieve the goal of evaluating the attentional effects of other pokes, and other types of rhetorical figures, while maintaining the similarity between the scripts as much as possible.

6.6.5 Developing a Responsive AI Agent

Recall that the experiment design is deceptive in the sense that some participants believed that it is a study regarding the chatbot. A direction of future development is to implement a real chatbot as part of the experiment and a requirements elicitation system. With sufficient resources, a more responsive agent could be implemented to enhance the experiment since the current AI agent represented by a chatbot does not respond to questions initiated by the user. However, potential inconsistencies may arise from a user's response in the presence of this feature since the agent is now able to interact with and guide the user with the agent's response to the questions. This may not be an advantage for this experiment but a real requirements elicitation system would benefit from a responsive AI agent. The interaction and guidance from an analyst is important during a real-world requirements elicitation interview, since the goal is to derive a detailed software requirement specification from user's response. The experience may be further improved by implementing the chatbot with a graphical interface. A potential application of this system is to help students or designers to evaluate their own ideas. When an idea is generated by a customer, the customer may use this system to test the robustness of his/her idea before the development phase.

6.6.6 Human Analyst

Although it was stated that this experiment focused on rhetorical figures generated by text only, it is possible to conduct the experiment with a human analyst that follows the scripts during the interview. Although there is no plain language, the human analyst can be told to refrain from using certain figures such as poke in Mode $\mathcal{P}$ and purposely using certain figures in Mode $\mathcal{R}$. A human analyst being part of the experiment may introduce

uncontrolled unknown variables. For example, the conversation may inadvertently diverge to other topics and the human analyst may use other rhetorical figures, possibly impacting the cause of the interview in either modes.

6.6.7 Rhetorical Figure and Final SRS

The connection between rhetorical figures used during requirements elicitation process and the final software requirement specification (SRS) has yet to be established. A new but similar experiment design can be implemented in the full requirements engineering cycle in order to study the connection between rhetorical figures and the final SRS. The current experiment design can be incorporated as a module of the requirements elicitation phase.

6.7 Summary

The experiment design and result reported in this chapter focus on the effects of rhetorical figures during the process of requirements elicitation which is a critical component in requirements engineering. I conducted interviews to simulate a scenario in which an AI analyst communicates with a participant who has an idea for educational software. Two conditions were set by the mode of the agent. In Mode $\mathcal{P}$, the agent used only plain language. In Mode $\mathcal{R}$, the agent used the three plokas, i.e., anadiplosis, epanalepsis, and mesodiplosis. Participants were asked to fill out two questionnaires before and after the interview. The results were analyzed by the use of three measures:

1. **Level of detail**, of the descriptions that the participants provided about their software ideas, such as purpose, targeted user and important features of the software both before and after the interview: In most cases, participants were able to provide more details and specific features instead of general descriptions after the interview. However, there was no significant distinction between Modes $\mathcal{P}$ and $\mathcal{R}$.
2. **Favorability of impressions**, of the participants toward the agent, based on the result of 5-point Likert scale only in Q2, after the interview. Participants rated higher score for clarity and friendliness and average score for naturalness, engagement and efficiency for AI agents in both modes. Mode $\mathcal{P}$ agent received higher mean score in naturalness, clarity, and friendliness, while Mode $\mathcal{R}$ agent received higher mean score in engagement and efficiency. However, again, there was no significant distinction between Modes $\mathcal{P}$ and $\mathcal{R}$.

3. **Memorability of the interview**, measured by the responses to *q5* in Q2, i.e., **Please recite/rephrase a line that you can remember from the agent**. It evaluates which question or statement stood out from the agent during the interview with an emphasize on the statement of education. Participants in Mode $\mathcal{R}$ were more likely than participants in Mode $\mathcal{P}$ to recall concepts conveyed by the questions and the statement of education, all of which were embedded with certain pokes. Despite having dealt with longer sentences, participants in Mode $\mathcal{R}$ were more often than participants in Mode $\mathcal{P}$ able to recite the statement of education verbatim.

The results of this experiment provide a small bit of evidence that the use of certain pokes in a discourse might generate attentional effects that increase salience and memorability of the discourse. Out of the three null hypothesis, only $H3$ was rejected. This rejection aligned with the discussion on memorability by Harris et al. [106]. However, the results of this experiment are inconclusive. Nevertheless, there is always the possibility of Type I and Type II error. More data is needed to consolidate the result. Another improvement needed is to modify the interview scripts to incorporate multiple pokes. The power of a single poke in a sentence may just be too weak in the setting of this particular experiment. The effect of collocation of multiple pokes should be investigated in the future.

The design of this experiment is a contribution to the study of attentional effects of rhetorical figures. With modifications on the modules of this experiment such as the questionnaires and interview scripts, the experiment design can be applied to study attentional effects of various rhetorical figures and other domains of application. Continuing research in pokes and rhetorical figures in general in areas such as requirements elicitation and other areas that involve natural language would be beneficial, since rhetorical figures are naturally embedded in human language [103].

Chapter 7

Conclusion and Future Work

7.1 Conclusion

Rhetorical figures are naturally embedded in natural language that carry essential semantic and pragmatic information that most current AI/NLP systems ignore. This thesis focuses on a specific class of rhetorical figure called Ploke, i.e., rhetorical figures of perfect lexical repetition. Although it has a simple form at first glance, a ploke may consist of a complex structure of lexical repetitions that are interconnected. Ploke generates attentional effect also in the sense that it creates mnemonic and aesthetic effects that increase the salience, aesthetic pleasure, memorability, and stabilizes reference of concepts conveyed by interlocutors. The choice of ploke as the focus of this research is as follows: Ploke is ubiquitous, can be easily tracked and is language independent. Ploke is the perfect lexical repetition, and perfect lexical repetition is ubiquitous in all languages and is easily found in a vast majority of context, conversations, passages of natural language. Perfect lexical repetition can be easily tracked. A trivial search highlights any lexical repetition. However, these simple syntactical patterns carry much information with potentials yet to be discovered. As demonstrated by the neurocognitive path proposed in this thesis, information and knowledge about these repetition patterns, classified as neurocognitive affinities triggered by the forms of pokes, indicates a range of attentional effects such as the mnemonic effect on the receiver generated by the passage carrying pokes.

The contribution of this research is three-fold: the neurocognitive path of rhetorical figure, the design of Ploke Ontology and its applications, and the empirical study of pokes in requirements elicitation interviews.

Firstly, this thesis proposed the neurocognitive path of rhetorical figure, which is an overall diagrammatic model that enhances and represents theories such as form-function pairing, neurocognitive affinities and attentional effects proposed by contemporary rhetorical figure researchers such as Fahnestock and Harris. the neurocognitive path outlines the detailed components of concepts related to plope and rhetorical figures in general and their connections as modules that are needed to be developed computationally with ontological models. Indeed, components in the neurocognitive path cannot be exhaustive. It serves as an overall blueprint for future development directions and modules.

This thesis lays the foundation of the neurocognitive path for plope, a family of schemes. Plope in turn is a subtype of rhetorical figures. Other paths that involves the connection between form and function, and the connection from function to attentional effects, are being researched.

The Plope Ontology proposed in this thesis is a KR model that represents knowledge regarding plope. The ontology includes classes and properties describing the general level concepts such as rhetorical figure, form, function, linguistic elements, neurocognitive affinity and attentional effect. The ontology classified plope as a family of scheme figures that includes subclasses such as conduplicatio, anadiplosis, antimetabole, mesodiplosis, etc. rather than an isolated rhetorical figure following the view of Harris [99]. The ontology focuses on modeling knowledge along the neurocognitive path of plope that describes how attentional effects are generated by a rhetorical figure has on a receiver. That is, the path **Rhetorical Figure** $\rightarrow$ **Form** $\rightarrow$ **Neurocognitive Affinity** $\rightarrow$ **Attention Effect** which is referred to as the **Form branch** in this thesis.

Plope Ontology models classification and representation of repetition and position, both are primary neurocognitive affinities triggered by the form of a plope. For example, the class **Anadiplosis** triggers the **Cross-Boundary Repetition**, a subclass of **Repetition** in which positions of elements are specified as instances of **Relative Position**, a subclass of **Position**. Similarly, **Epanaphora**, **Mesodiplosis** and **Epiphora** trigger specific types of repetitions in which positions of the elements, e.g., `rep1e1_pos` and `rep1e2_pos`, are instances of classes **Initial**, **Medial**, and **Final** respectively, all of which are subclasses of **Relative Position**. The ontology represents nested repetition with the class **NestedRep**, which are perfect lexical repetitions involving other perfect lexical repetitions. The ontology represents nested repetition up to three levels of abstraction with subclasses **N¹Rep**, **N²Rep**, and **N³Rep**. For example, the repetition triggered by **Antimetabole** is **Reversed Repetition**, a subclass of **N¹Rep**, which in turn is a subclass of **NestedRep**. Reversal is the alternation of positions of **Elements** that are part of a **Reversed Repetition**, a subclass of **NestedRep**, in which the **Elements** are **SingleReps**.

Thus, all perfect lexical repetitions can be represented as instances of single and nested repetitions in the Ploke Ontology. The Ploke Ontology can be implemented in AI/NLP systems to enable the ability to infer knowledge about pokes when perfect lexical repetitions are encountered. An AI/NLP system that implements the Ploke Ontology is able to infer about knowledge related to pokes including the types of repetition, tokens being repeated, their positional information, and whether it is a complex pokes that consists of other pokes figures. The neurocognitive affinity triggered by the perfect lexical repetition is now revealed by understanding the single and nested repetitions of the pokes that exist in the passage. These information regarding perfect lexical repetitions that were once omitted can be taken advantage of. It is no longer the case that an AI/NLP system merely highlights the lexical repetitions without any meaning or background knowledge. By realizing specific repetitions and positions with knowledge of pokes, an AI/NLP system can now recognize, reason and generate passages with pokes which can generate attentional effects such as salience, aesthetic pleasure, and mnemonic effects.

Applications of the Ploke Ontology include merging with other rhetorical figure ontologies to create a more robust ontology, and accommodating current relational databases, such as the Rhetoricon, through ARM. Since pokes is ubiquitous in natural language and ontologies are “stand-alone”, it is possible to implement the Ploke Ontology in any AI/NLP system that wishes to take advantage of the knowledge and information of pokes in terms of recognition, reasoning, and generation. In addition, pokes is language independent. Therefore, the Ploke Ontology is compatible with AI/NLP systems in various languages, as demonstrated by merging the Ploke Ontology with the Serbian RetFig and the German GRhOOT ontologies.

The merge of multilingual rhetorical figure ontologies demonstrated the capability of combining multiple rhetorical figure ontologies. Pokes Ontology served as a base that is compatible with other rhetorical figure ontologies developed for other languages such as Serbian and German. This is due to the property of language independence of pokes. Indeed, pokes is not the only family of scheme that is language independent. Therefore developing ontologies for other scheme figures would consolidate and expand the so-called “base” which is able to incorporate more rhetorical figure ontologies for more languages. The resulting merged ontology for pokes is a combination of three different ontologies that tackles not only multilingual differences but also conceptual and terminological inconsistencies. It is tightly connected but still modular. This thesis has shown the representations of different pokes figures in the ontologies and their definitions. The inconsistencies were identified to be later resolved.

I conducted an empirical experiment to study the attentional effect of three pokes: anadiplosis, mesodiplosis and epanalepsis in the settings of a fictional requirements elicita-

tion interview that involves a fully-developed AI agent that is capable of playing the role of a requirements analyst. Role-playing interviews were conducted in which a participant played the role of a customer who had an idea of an educational software, while the role of an AI requirements analyst was played by a chatbot controlled by the experimenter as the Wizard of Oz following a script dedicated to each of the experiment condition, i.e., Mode $\mathcal{P}$ or $\mathcal{R}$. In Mode $\mathcal{P}$ the agent used only relatively plain language while it made use of the aforementioned pokes in Mode $\mathcal{R}$.

The experiment analyzed the distinctions between Mode $\mathcal{P}$ or $\mathcal{R}$ in terms of levels of detail, favorability of impressions towards the analyst, and memorability towards a statement of education made by the analyst during the interview. However, only results on memorability provided significant distinctions between the two modes, in which participants in Mode $\mathcal{R}$ were more likely to recall the statement of education than participants in Mode $\mathcal{P}$.

The design of this experiment is a contribution to the research of attentional effects of rhetorical figures. The experimental design can be modified to include various rhetorical figures and can be applied to domains other than requirements elicitation.

The empirical experiment serves as an investigation of the connection between pokes and the attentional effects they generate. Besides, investigating the attentional effect of pokes, a crucial component of the neurocognitive path that is proposed in this thesis, the study contributes also to the field of Requirements Engineering by establishing the idea that the use of rhetorical figures may impact the results of the requirements elicitation process. The connection is novel to both fields of Requirements Engineering and Rhetorical Figures.

The next section discusses potential future research directions based on this thesis.

7.2 Future Work

The neurocognitive path for rhetorical figures is a diagrammatic summary and a blueprint of the design of components that should be researched in the area of computational rhetoric that specializes in rhetorical figures. Each node indicates a component, e.g., receiver, passage, rhetorical figure, form, function, neurocognitive affinity, etc. of the figure that should be formally represented with computational ontological models. The ontology is able to formally capture knowledge of components on the form branch of the neurocognitive path. There are other components that are represented simply with placeholders that need to be carefully researched and formally represented as part of future research direction. These

components include receiver, passage, other aspects of linguistic element, more importantly, function and attentional effects.

The next step is to represent information and knowledge regarding attentional effects such as salience, aesthetic pleasure, and mnemonic effect mentioned throughout this thesis. The link between neurocognitive affinity and attentional effect is the final connection on the neurocognitive path. This connection needs to be established to formally represent knowledge and information regarding attentional effects. However, this task requires collaborations from researchers in multiple disciplines to achieve in the future, along with many other future work and potential research directions. A formal representation of attentional effects completes the neurocognitive path (form path) in terms of ontological representations. No need to say, it would be of great value if an AI/NLP system is able to infer information regarding attentional effect. Inference about attentional effect opens the door to aspects of human minds such as feelings, emotion, etc. Of course, just as human minds, this cannot be relied purely on deductive reasoning. However, being able to represent and infer certain information regarding attentional effects would enable the ability to “feel” the emotional and implicit information carried by a passage or utterance in natural language. This requires collaborative work from areas such as cognitive science, psychology, neuro-science, and rhetoric or linguistics in general.

The neurocognitive path shows a dashed line between form and function. It is the unknown link between form and function which needs to be established and researched to reveal its details. It is possible that this link does not exist directly between form and function, and the Form Branch of the neurocognitive path is the linkage between form and function. Of course, how function connects to the form path is an important research question.

Harris [102] refers to an example of epanalepsis as “tautological epanalepsis”. Similar approach that classifies rhetorical figures based on their functions can be seen in other of his work involving Construction Grammar (CxG)[101]. It is not difficult to observe the similarity between a CxG model and an ontological model in the context of rhetorical figures. A construction such as *AMP* (antimetabole-mesodiplosis-parison) is basically a compound figure that can be viewed as a subclass of *Ploke* in the Ploke Ontology that consists of antimetabole and mesodiplosis. There is also parison, but it does not affect its classification under Ploke. It can also be a subclass of a class *Parison* in a corresponding ontology that includes this class. For example, [Example 2.1.1](#) can be represented as a passage that contains an instance of the new class AMP that consist of the instances *anti1* and *meso1* which are contained by the passages *all ... one, one ... all* and *... for ... for ...* respectively. The class AMP can be connected to an instance of *NestedRep* (nested repetition) in the same way as representing the perfect lexical repetition of [Example 2.1.1](#).

The Ploke Ontology represents nested repetition with up to three levels of abstraction. Although it is sufficient for practical purposes within the domain of natural language, nested repetition with higher abstraction levels should be considered. The design of the Ploke Ontology can be adapted to expand to other types of repetitions such as syllable repetition, consonant repetition etc. to represent other figures of repetitions such as alliteration, assonance, polyptoton, etc. The Ploke Ontology also serves as a foundation to be implemented in and connected with other rhetorical figure ontologies to represent various schemes and tropes. As demonstrated by Gawryjolek [77], O'Reilly and Mitrović [162], rhetorical figure ontologies can be connected with existing knowledge bases such as DBPedia [13] to represent tropes such as litotes. The Ploke Ontology is essential when addressing rhetorical figures such as antanaclasis in which lexical repetitions occur with identical signans but different signata.

As discussed by Harris [102], epiphora always brings rhyme thus assonance. This is an example of facts of pokes and rhetorical figures that can be entailed through structured knowledge such as an ontology. Figure collocation of pokes can be represented using **NestedRep** in the Ploke Ontology. A direction of future research is to develop conceptual models that represents figure collocation in other rhetorical figures. The ability to infer about figure collocation would be extremely valuable.

In terms of applications of rhetorical figure ontologies in general, future work includes the establishment of a generalized framework for ontologies in the domain of rhetorical figures, as also suggested by researchers in the field of rhetorical figure ontology [163, 220]. As mentioned by Wang et al. [220], this framework could be similar to the CIDOC-Conceptual Reference Model [56] that is used in the domain of cultural heritage information. It is an ontology which is restricted to predefined semantics that are specific in the domain of cultural heritage. For the domain of rhetorical figures, a standard notation of text elements is required [103]. Furthermore, more figures can be combined in one unified ontology or an ontological suite as envisaged by Di Marco and Harris [103, 106].

The work cited in Chapter 2 has paved the way for combining ontologies of rhetorical figures in a potentially generalizable way that involves much domain-specific knowledge. Rhetorical figure ontologies can be merged following methods presented by Wang et al. [220] which is also discussed in Chapter 5. An automated tool that incorporates rhetorical figure domain knowledge will greatly simplify the process as more rhetorical figure ontologies are being developed.

Even though LLMs became increasingly popular during the time I was doing the research for this thesis, the thesis does not focus on LLMs, because they are not directly relevant to the questions that I was researching. Nevertheless, Chapter 1 discusses some of

the shortcomings of LLMs when they encounter rhetorical figures. Recent study suggests that LLMs struggle even with pokes with simple syntactical patterns such as epanalepsis and mesodiplosis [64]. Integration of ontologies and knowledge graphs into RAG systems have been an increasingly popular area of research [76]. An ontology-grounded RAG (OG-RAG) method enhances the performance of LLMs when domain-specific knowledge is involved [202]. Thus, the Ploke Ontology and other rhetorical figure ontologies have the potential to enhance LLMs by providing domain knowledge, increasing accuracy, robustness, and explainability when rhetorical figures are involved. In general, an ontological approach was never meant to replace or contradict a deep learning approach. The recent research of the discipline of neuro-symbolic AI looks into the combination of a symbolic approach, e.g., ontologies and deep learning [21, 50, 75].

Additionally, ontology is an essential factor in the development of explainable AI, which is a key attribute of a trustworthy AI system [3, 44]. Ontologies have been developed to aid explainability of AI systems in multiple domains [37, 42, 49, 80, 143, 212].

Future work of the empirical study includes an improved experiment design that incorporates pokes with figure collocation rather than single pokes. It is worthwhile to conduct a larger scale experiment with the improved experiment design in terms of the rhetorical figures being incorporated. The experiment design can also be applied to other rhetorical figures and other domain of applications.

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APPENDICES

Appendix A

Notational Conventions

Table [A.1](#) summarizes the notational conventions for all the kinds of text that appear in this thesis. This table was introduced as Table [1.1](#) in Section [1.6](#).

Text Type	Convention	Example
Regular text	Roman	-
Headers	Boldfaced	-
Introduction of terms	<i>Italics</i>	<i>ploke</i>
Mathematical formula	Standard mathematical notation	$A \wedge B$
Quotations other than examples	Each quotation is surrounded by quotation marks.	“some quotes”
Examples	Example texts are in Typewriter font.	all for one; all
Single character examples	Examples with only one character are surrounded by single quotation marks.	‘a’, ‘b’, ‘c’
Class names in ontologies	Each class name is in Sans serif with the first letter capitalized.	Ploke
Relation names in ontologies	Each relation name is in Sans serif with the first letter not capitalized.	for(all,one)
Relation parameters of type example	A parameter of type example is in slanted <i>Typewriter</i> font.	for(<i>X,Y</i>)
Relation parameters of type class	A parameter of type class is in slanted <i>Sans serif</i> font.	for(<i>X,Y</i>)
Noteworthy repetitions in pokes	Occasionally, each occurrence of a repeated phrase in an example is <u>underlined</u> .	<u>easy</u> come, <u>easy</u> go.
Entity sets and table names	Entity sets and table names are in uppercase Typewriter	LABEL

Table A.1: Notational Conventions of This Thesis.

Appendix B

List of Rhetorical Figures

Some definitions in the this appendix are adapted from Harris and Di Marco [104] and O'Reilly et al. [181].

B.1 Rhetorical Figure of Perfect Lexical Repetition

Anadiplosis: the repetition of a lexeme or lexical group on either side of a clause or phrase boundary.

Anaphora: a synonym for epanaphora.

Antimetabole: the proximal occurrence of the same two lexemes or lexical groups in reverse orders.

Conduplicatio: unpatterned lexical repetition.

Epanalepsis: lexical repetition at the beginning and ending of a phrase or clause.

Epanaphora: the occurrence of the same lexeme or lexical group at the beginning of proximal clauses or phrases. A synonym for anaphora.

Epiphora: a synonym for epistrophe.

Epistrophe: the occurrence of the same lexeme or lexical group at the end of proximal clauses or phrases, a synonym for epiphora.

Epizeuxis: perfect lexical repetition when a lexeme or lexical group recurs immediately.

Gradatio: a sequence of anadiploses.

Mesodiplosis: the occurrence of the same lexeme or lexical group in the middle of proximal clauses or phrases.

Ploke: schemes of perfect lexical repetition, in which the occurrence of the lexeme or lexical group being repeated have the same form and meaning. Common alternate spellings are plocé or ploche. In this thesis, Ploke is defined as a class of schemes of perfect lexical repetition in which the occurrence of the lexeme or lexical group being repeated are constrained by relative position, syntactic position, or sequential order.

Symploce: the occurrence of the same word or word group at the beginnings of two or more proximal phrases or clauses while another word or word group occurs at the ends of those same phrases or clauses.

B.2 Other Rhetorical Figures

Alliteration: a scheme, consecutive use of words with the same initial consonants.

Antanacsis: a trope, the repetition of a lexeme or lexical group with the same form but different meaning.

Antithesis: a trope, both a figure and a class of figures: proximally opposed predications, through antonyms or affirmatives and negations.

Assonance: the repetition of the sound of a vowel.

Chiasmus: often used as a synonym for antimetabole, sometimes used as a synonym for other members of the Chiasmus Suite (see below). In the Rhetoricon group at the University of Waterloo, it is recognized as a general pattern of reverse repetition of any linguistic constituent, with different figures defined by which constituents are implicated.

Chiasmus Suite: a group of figures, including schemes, tropes, and moves in which constituents repeat in reverse order, prominently including antimetabole.

Incrementum: a series of three or more words from the same semantic domain, in which each subsequent word in the series increases along some metric such as size, quantity, intensity, status, etc.

Irony: a trope, both a figure and a class of figures: deviations of conventional expectations of speaker intention, often in an exaggeratedly opposite way.

Isocolon: the proximal repetition of the same prosodic contours, such as same syllable count or length.

Hyperbole: a trope, distending the valence of a characterization to an extreme.

Metaphor: a trope, both a figure and a class of figures: a cross-domain property mapping with no overt comparative construction.

Metonymy: a trope, a word correlated with a domain used to represent the domain.

Oxymoron: a type of antithesis. The juxtaposition of words with opposite semantic properties, often in adjective-noun pairs.

Parison: the proximal repetition of the same syntactic pattern.

Polyptoton: the use of one word stem in a variety of morphological instantiations.

Rhyme: proximal repetition word-final syllables.

Sarcasm: a type of irony (and colloquially often a synonym for irony), therefore a chroma, which demeans through expressions that distend semantic properties.

Synecdoche: a trope, which uses a part of the concept or object to represent the whole.

Appendix C

Full Results of the Experiment

This appendix shows frequency of each score assigned and results evaluated using additional scales.

C.1 Question 1 – Question 3

C.1.1 Frequency

Dataset	NC	SD	SN	SD or SN	D	N
W1P	36	12	10	0	7	10
W1R	31	14	9	0	5	16
W2P	15	17	10	6	13	14
W2R	17	10	12	13	12	11
B1P	26	13	7	5	14	10
B1R	31	12	13	4	7	8
AVE-P	25.67	14	9	3.67	11.33	11.33
AVE-R	26.33	12	11.33	5.67	8	11.67

Table C.1: Frequencies of each assignment in for responses to q1–q3 Mode $\mathcal{P}$ and $\mathcal{R}$

On average, Mode $\mathcal{R}$ has more Ns and SNs than does Mode $\mathcal{P}$. Mode $\mathcal{P}$ has more Ds and SDs than does Mode $\mathcal{R}$. Mode $\mathcal{R}$ has slightly more NCs than does Mode $\mathcal{P}$. The results are shown in Table [C.1](#).

C.1.2 Additional Scales

Recall that in the original score, the evaluators assigned NC, SD/SN, or D/N, to responses of $q1$ – $q3$. Then scores 0, 1, and 2 were assigned to each category respectively. In order to analyse the datasets in depth, three additional evaluation scales were used, i.e., scale-2, scale-3, scale-unanimous. Full definition of the original scale can be found in Section 6.2.2 in Chapter 6.

Scale-2

Evaluation	W	p-value	Normal?
W1-P	0.8597	0.002709	No
W1-R	0.8721	0.004768	No
W2-P	0.7538	0.00004227	No
W2-R	0.7479	0.00003457	No
B1-P	0.8585	0.002566	No
B1-R	0.0.8739	0.00519	No
AVE-P	0.9455	0.1979	Yes
AVE-R	0.9574	0.3654	Yes

Table C.2: Shapiro Wilk Test for responses of $q1$ – $q3$ in scale-2

Dataset	Change Mean	Change SD	Distinction	p-value of Distinction
W1-P	1.56	0.9831	−0.2	0.5006
W1-R	1.76	0.9499		
W2-P	2.4	0.6325	0.08	0.787
W2-R	2.32	0.7332		
B1-P	1.96	0.8236	0.2	0.4268
B1-R	1.76	0.8616		
AVE-P	1.9733	0.6104	0.0266	0.8906
AVE-R	1.9467	0.6372		

Table C.3: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-2

The first scale uses binary scores to indicate change or no-change instead of assigning change scores. That is, every response to $q1$ to $q3$ in Q1 and Q2 in both Mode $\mathcal{P}$ and $\mathcal{R}$ is evaluated with NC or C, in which C is any of SD, SN, D, and N in the original scale.

NC is assigned a score of 0, C is assigned a score of 1. This scale is referred to as scale-2. The modified metric is shown as follows:

For each x & n , equal to one of “P” & 1, “U” & 2, and “F” & 3,

π ’s $\Delta x = 0$, if and only if π ’s change for qn from Q1 to Q2 = “NC”,

π ’s $\Delta x = 1$, if and only if π ’s change for qn from Q1 to Q2 = “C”, where “C” is any of “SN” or “SD” or “N” or “D” in the original scale.

Scale-3

The original scale assigns a D or N when there two or more phrases name a new PUF or give more details. Scale-3 distinguishes two phrases and three phrases by adding two assignments DD and NN. DD is assigned when more details were given in three phrases. NN is assigned when more PUFs were named in three phrases. Both DD and NN receives a score of 3.

That is, there are three new details or new names in the change of a response from Q1 to Q2. Additionally, the case in which both SD/D and SN/N can be assigned to an evaluation. The following new categories can be assigned:

Let π be a participant.

- π ’s change for qn from Q1 to Q2 is “NN”
if and only if
 - the at most 3 phrases of π ’s answer for qn in Q2
 - merely name at least 3 more PUFs of qn ’s topic than do
 - the at most 3 phrases of π ’s answer for qn in Q1.
 (i.e., merely name at least 3 more purposes, at least 3 more users, or at least 3 more features)
- π ’s change for qn from Q1 to Q2 is “DD”
if and only if
 - the at most 3 phrases of π ’s answer for qn in Q2
 - give at least 3 more details about PUFs of qn ’s topic than do
 - the at most 3 phrases of π ’s answer for qn in Q1, but
 - for exactly the same PUFs that are named
 - in π ’s answer for qn in Q1.

For each x & n , equal to one of “P” & 1, “U” & 2, and “F” & 3,

π 's $\Delta x = 0$, if and only if π 's change for qn from Q1 to Q2 = "NC",
 π 's $\Delta x = 1$, if and only if π 's change for qn from Q1 to Q2 = "SN" or "SD", and
 π 's $\Delta x = 2$, if and only if π 's change for qn from Q1 to Q2 = "N" or "D", and
 π 's $\Delta x = 3$, if and only if π 's change for qn from Q1 to Q2 = "NN" or "DD".

Note that dataset W1 is not considered in this scale since I did not track DD and NN while evaluating W1.

Evaluation	W	p-value	Normal?
W2-P	0.8849	0.008726	No
W2-R	0.8747	0.005385	No
B1-P	0.944	0.1835	Yes
B1-R	0.8877	0.01002	No
AVE-P	0.8978	0.01644	No
AVE-R	0.9227	0.05917	Yes

Table C.4: Shapiro Wilk Test for responses of q1–q3 in scale-3

Dataset	Change Mean	Change SD	Distinction	p-value of Distinction
W2-P	4.04	2.0294	0.44	0.54
W2-R	3.6	1.7436		
B1-P	3.28	1.9083	0.76	0.1741
B1-R	2.52	1.6278		
AVE-P	3.66	1.5891	0.6	0.2657
AVE-R	3.06	1.3417		

Table C.5: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-3

Scale-unanimous

The third scale is to eliminate all data that is not agreed between the evaluators. That is, only the agreed data entries were kept. This scale produced only a small number of entries of data as shown in Table C.7.

Evaluation	W	p-value	Normal?
W1-W2-P	0.8664	0.2423	Yes
W1-W2-R	0.7309	0.06164	No
B1-W1-P	0.9302	0.5766	Yes
B1-W1-R	0.9543	0.8729	No
B1-W2-P	0.9271	0.6029	Yes
B1-W2-R	0.7803	0.02392	No

Table C.6: Shapiro Wilk Test for responses of q1–q3 in scale-unanimous

Dataset	Change Mean	Change SD	Sample Size	Distinction	p-value of Distinction
W1-W2-P	3.1667	0.2618	6	−0.8333	0.2522
W1-W2-R	4	1.1547	4		
B1-W1-P	2.5	0.9258	8	−0.2143	0.7831
B1-W1-R	2.7143	1.7995	7		
B1-W2-P	4	1.8257	7	0.875	0.2629
B1-W2-R	3.125	1.3562	8		

Table C.7: Distinction in scores between Mode $\mathcal{P}$ and $\mathcal{R}$ in Scale-unanimous

C.1.3 Categorize by PUF

The results are also categorized by q1, q2, and q3 in order to investigate the distinction of each category of P, U, and F. As shown in Table C.9, there is also no significance of Mode $\mathcal{R}$ better than Mode $\mathcal{P}$ when results are categorized by questions.

There is also no significance of Mode $\mathcal{R}$ better than Mode $\mathcal{P}$ when results are categorized by P, U, or F. That is, the results of $q1$, $q2$, and $q3$ are analyzed separately. Results from scale-bin and scale3 also did not show significance in distinction between Mode $\mathcal{P}$ and $\mathcal{R}$. Results for these evaluation scales are shown in Appendix .

C.2 Question 4

C.2.1 Frequency

Table C.10 shows the frequencies of each category rated by participants in Modes $\mathcal{P}$ and $\mathcal{R}$.

Evaluation	W	p-value	Normal?
q1-P	0.9476	0.2208	Yes
q1-R	0.9283	0.07936	No
q2-P	0.7932	0.0001753	No
q2-R	0.8301	0.0007556	No
q3-P	0.9154	0.04033	No
q3-R	0.888	0.01014	No

Table C.8: Shapiro Wilk Test for responses of q1–q3 in scale-unanimous

Question	Change Mean	Change SD	Distinction	p-value of Distinction
q1-P	1.093	0.503	0.013	0.9057
q1-R	1.08	0.605		
q2-P	0.653	0.720	0.13	0.8392
q2-R	0.523	0.607		
q3-P	1.133	0.588	0.04	0.8425
q3-R	1.093	0.467		

Table C.9: Distinction in scores in the dataset CON categorized by questions between Mode $\mathcal{P}$ and $\mathcal{R}$

C.3 Question 5

C.3.1 Additional Scales

There is significantly more “None”s in Mode $\mathcal{P}$ versus in Mode $\mathcal{R}$. There are 6 responses and 1 response respectively in which the participants answered **I see**, **Thank you** or **Please give me a description of the software** or similar. Implementing scale-2 by assigning all “None” a score of 0 and all other categories 1, a Mann Whitney U test (the dataset does not assume normality with $W_{\mathcal{P}} = 0.5317$ and $W_{\mathcal{R}} = 0.2063$) shows that the distinction between Mode $\mathcal{P}$ ($M = 0.76$, $SD = 0.43589$) and $\mathcal{R}$ ($M = 0.96$, $SD = 0.2$) is significant ($p = 0.04366$).

Scale-NQ combines the number of “None” and “Question” and assign 0 to these categories, then assign 1 to other categories involving mentioning the statement of education. The average of Mode $\mathcal{P}$ ($M = 0.24$, $SD = 0.43589$) is slightly lower than Mode $\mathcal{R}$ ($M = 0.32$, $SD = 0.476095$). However there is no significance in the distinction between the two modes.

Count	Naturalness	Engagement	Efficiency	Clarity	Friendliness
1P	1	0	0	0	0
1R	1	1	0	0	0
2P	1	5	3	2	0
2R	5	0	2	1	0
3P	6	6	11	0	0
3R	4	5	6	2	2
4P	9	7	2	5	5
4R	9	13	10	8	5
5P	8	7	9	8	20
5R	6	6	7	14	18

Table C.10: Count of impression score in Mode $\mathcal{P}$ and $\mathcal{R}$

	Mode $\mathcal{P}$	Mode $\mathcal{R}$
M	0.76	0.96
SD	0.43589	0.2
p-value	0.04366	

Table C.11: Sample mean for dataset q5-scale-2 (None = 0, otherwise assign 1)

	Mode $\mathcal{P}$	Mode $\mathcal{R}$
M	0.24	0.32
SD	0.4359	0.4761
p-value	0.5329	

Table C.12: Sample mean for dataset q5-scale-NQ (None = Question = 0, otherwise assign 1)

Appendix D

Pilot Study

A pilot study was conducted prior to the full-scale experiment. This appendix includes information regarding the materials used and the participants of the pilot study. The overall process of the experiment remained the same.

Changes Made in the Full-Scale Experiment

Some details have been changed when conducting the full-scale experiment. For example, the pilot study was done in person while the full experiment was done online. The scripts were also modified in the full experiment.

	Pilot Study	Full-Scale Experiment
# of participants	6	50
Format	In-person	Online
# of questions	5	5
Software Description	Rephrased	
Questionnaires		
Interview Script		

Table D.1: Frequencies of each assignment in for responses to q1–q3 Mode $\mathcal{P}$ and $\mathcal{R}$

Materials

Below are the software description and questionnaires that were handed to the participants during the pilot study.

Software Description:

The description of software provided to each participant is shown below. Each participant used approximately 10 minutes, to brainstorm privately about the software before his/her interview began privately.

You have an idea of a software that tracks and evaluates a student's progress and skill in an undergraduate course.

Questionnaire

As described previously, each participant answered Questionnaire 1 before and Questionnaire 2 after his/her interview. Both Questionnaires 1 and 2 asked the same first three questions:

1. Please use at most three words/short phrases to describe the purpose of this software.
2. Please describe the targeted user groups of this software. Please be as specific as possible (e.g., type of students)
3. Please list the top 3 features of this software

Questionnaire 2 had extra questions:

4. Please rate the conversation experience you had with the analyst (1 = highly disagree, 5 = highly agree)
 - The conversation felt natural
 - The agent did not bore me
 - The interview was efficient and productive
 - The agent was clear with its statements
 - The agent was friendly when talking to me
5. Please recite/rephrase a line that you can remember from the agent.

Date: 27/12/2018
Time: 12:37pm/pm
Participant:
Email:

This study consists of two questionnaires and a role-playing interview. You are asked to play the role of a customer who has an idea about a software and is having an interview with a software development company to discuss your idea. The software development company is fully automated, so instead of an in-person interview, the company has built a chatbot that is able to discuss your idea with you. A general description of the software is provided below.

Software Description:
You have an idea of a software that tracks and evaluate a student's progress and skill in an undergraduate course.

Questionnaire 1
Please use at most 3 words/short phrases to complete the following questions

- Please describe the purpose of this software.
Evaluate student learning Track learning progress Identify areas of improvement
- Please describe the targeted user groups of this software. Please be as specific as possible (e.g., type of students)
University students 1st and 2nd year students who use need more help in
- Please list the most important features of this software
Visual navigation for navigation for tracking/evaluation making useful learning suggestions providing learning resources progress
- Please rate the conversation experience you had with the analyst (1 = highly disagree, 5 = highly agree)
5

The conversation felt natural

1	2	3	4	5
Strongly disagree	disagree	Neutral	Agree	Strongly agree

The agent did not bore me

1	2	3	4	5
Strongly disagree	disagree	Neutral	Agree	Strongly agree

Date: 27/12/2018
Time: 1:01pm/pm
Participant:
Email:

The interview was efficient and productive

1	2	3	4	5
Strongly disagree	disagree	Neutral	Agree	Strongly agree

The agent was clear with its statements

1	2	3	4	5
Strongly disagree	disagree	Neutral	Agree	Strongly agree

The agent was friendly when talking to me

1	2	3	4	5
Strongly disagree	disagree	Neutral	Agree	Strongly agree

- Please describe a line that is most memorable to you spoken by the agent. You do not have to recite, just provide a brief description, if you can remember any.
The most memorable line is when the agent ask what is the input and output of the "idea" for my software. The statement makes is an important question to ask for any product development. It forces me to think and imagine what the system will be like. In doing so, it clearly defines my ideas in the head and gave me some clarity to what is truly important for the system to do. In doing it, forced me to prototype the system manually. That is very useful for being clear, and hence I am impressed by the system and think it is very good/valuable

Figure D.1: Questionnaires used in study

Interview Script

A detailed interview script was written as part of the experimental design. There were four questions in the interview script. The phrasing of the questions in Mode $\mathcal{P}$ was different from in Mode $\mathcal{R}$. These questions were general and aimed towards high-level software requirement specifications thus they are likely to be included in a real-world requirements elicitation interview. A statement that highlights the importance of education software was also used as a connective between sentences. In both modes, the agent begins with the paragraph Hi, I will be the analyst who will discuss your idea with you. I will ask you some questions regarding your software. Take your time when answering each question and ends with Thank you for your time. That's all the questions I have. Connectives such as Thanks and I see were also used but appeared in the same order in both modes

Mode $\mathcal{P}$:

- Can you give me a description of this software?
- Education software is very important.
- What do you think is the most important feature of this software?
- What's the input and output of this software?

- Who will be the targeted user of this software?

Mode $\mathcal{R}$:

- Can you give me a description of this software?
- We learn through education, education gives knowledge, and knowledge is power. That's why education software is important.
- If you can advertise only one feature of this software, which one feature would that be?
- Let's think in terms of input and output. If this was a magical mixer, what goes in and what comes out?
- The users will be the final judges of the software, who do you think should be the judges of this software?

The interview scripts in both modes follow the same structure. The only difference is the use of rhetorical figures from Appendix B in Mode $\mathcal{R}$, e.g., the question `who will be the targeted user of this software?` was asked in the form of `the users will be the final judges of the software, who do you think should be the judges of this software?` which incorporates the analogy of referring to users as judges. The concept of `judge of the software` was emphasized by repeating the term in the question. The statement `Education software is very important` in Mode $\mathcal{P}$ was replaced by `We learn through education, education gives knowledge, and knowledge is power. That's why education software is important` in Mode $\mathcal{R}$. This statement contains a rhetorical figure called *gradatio* which consists of repetitions of words at the end and beginning of each phrase and pose a flow in the semantics, e.g., the words being repeated were `education` and `knowledge`. Note that the first question, `Can you give me a description of this software?`, was phrased in the same way in both modes since it is a generic question that simply opens the conversation.

Participants

There were 6 participants and each of the participants was a graduate student in the Cheriton School of Computer Science. There were 3 males and 3 females, with 1 male and 2 females selected to participate in the study in Mode $\mathcal{P}$, and 2 males and 1 female in Mode $\mathcal{R}$. Each participant used Google Hangouts on his/her own device during the interview session with the agent. One participant used a cellphone, and every other participant used either a laptop or a desktop.