PoEM: A Parser of Emotion Metaphors

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S.B., Aeronautics and Astronautics
Massachusetts Institute of Technology, 1992

SUBMITTED TO THE PROGRAM IN MEDIA ARTS AND SCIENCES,
SCHOOL OF ARCHITECTURE AND PLANNING,
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 1999

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ABSTRACT

Although metaphor is generally recognized as an integral component of everyday language, very few computational systems capable of understanding metaphoric utterances exist today. This thesis describes one approach to the problem and presents PoEM, a prototype system which recognizes and interprets metaphoric descriptions of emotions and mental states in single-sentence input. Building upon previous work in knowledge-based metaphor comprehension, this research adopts a *goal-driven* approach which assumes each metaphor is selected by a speaker for its aptness at serving a particular communicative goal. To identify these goals, an empirical analysis of metaphor distribution in song lyrics was performed, and typical communicative intentions and surface patterns were identified for the top five most frequently occurring metaphor groups. These intentions and surface patterns have been implemented as a set of metaphor templates and interpretation rules in PoEM, using the WordNet lexical database for supplemental semantic information. Evaluation of PoEM demonstrates fairly high accuracy but low recall.

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This research was sponsored by the News in the Future Consortium.

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Acknowledgments

This research would not have been completed without the support of many faculty members, friends, and family.

Many thanks are due to my thesis advisor Brian Smith for his unfailing support and invaluable assistance with the development and articulation of the ideas presented here. Without it, I might never have finished.

Kenneth Haase, my research advisor and thesis reader, introduced me to metaphor and many of the ideas on which this work is based. Thesis readers Walter Bender and Andrew Ortony provided valuable comments and insight. Other faculty at the MIT Media Laboratory, notably Whitman Richards and Justine Cassell, helped create a stimulating environment in which to explore and develop my interests. I am also indebted to Linda Peterson and Laurie Ward for their assistance and patience, and to Rebecca Prendergast for her help throughout my time in the program.

Special thanks go to Martin Hadis and other colleagues in the Machine Understanding Group: Warren Sack, Janet Cahn, Dan Gruhl, Mike Best, Zhonghui Xu and Kenichi Mori. Their efforts provided inspiration and insight for my own, and camaraderie helped make the process more enjoyable. Former officemates Savalai and Rob, shared not only their space but also their friendship.

Last, but certainly not least, I wish to thank my parents and family for their ongoing love and encouragement, and Mike Vande Weghe, who has stood by me through it all.

Table of Contents

List of Figures

List of Tables

1 Introduction

Metaphor arises when a familiar, well-understood concept (the *source*) is used to explain or structure another less-familiar one (the *target*). Although we tend to think of metaphor in literary terms, it occurs regularly in everyday linguistic communication as well. Consider this short excerpt taken from the Saturday Radio Address delivered on November 8th, 1997 by U.S. President Bill Clinton:

> This weekend the United States House of Representatives will decide whether America will continue to **move forward** with confidence **on the road to continued prosperity**, or **give in to fear** and fail to **seize** all the opportunities of the 21st century.

This single sentence contains at least four distinct metaphors: a reference to life as a journey (*"move forward...on the road"*); a reference to an abstract state as a physical location, specifically, a goal as a destination (*"to continued prosperity"*); the personification of fear as an adversary (*"give in to fear"*); and a reference to an abstract idea as a physical object (*"seize all the opportunities"*). In fact, empirical studies estimate that on average we use five metaphors per 100 words [Pollio et al. 90]. Consequently, any computational system which aims at general natural language understanding must address the problem of metaphor comprehension. If we wish to build computer agents which engage us in natural conversation, we must supply them with the means to understand our metaphors to help them derive appropriate inferences from our requests, and to generate appropriate responses.

Unfortunately, building a computational system for general metaphor understanding is a very difficult problem. First, metaphor interpretation may require specific knowledge about a particular domain (e.g. U.S. politics). Interpreting the President's quote requires prior knowledge about the role of the U.S. House of Representatives, the President, and how decisions are made. Second, metaphor interpretation requires access to "common-sense" or basic knowledge we assume all people possess. For example, we recognize the phrases above are metaphoric because we understand opportunities are not actually physical objects that can be seized, and that fear is not really a physical adversary. Additionally, in interpreting the utterance, we utilize our knowledge that to *"move forward"* is to make progress, and recognize the negative connotations of conceding to an adversary, to reach a conclusion about the President's personal viewpoints of the issue at hand. Third, the meaning of a metaphor often depends upon the current discourse context, suggesting that computational systems should include some means of tracking the discourse. A rather contrived but illustrative example of this is *"John is an elephant"* [Hobbs 83]. In one context we may interpret this to mean *"John has a good memory"* while in another the interpretation *"John walks very loudly"* is more appropriate. Finally, metaphor applies a *systematic mapping* of source domain knowledge to the target domain, which suggests that a computational system designed to handle novel metaphors must incorporate an analogical reasoning mechanism to determine the correspondence between the two [Gentner 83; Holyoak &

Thagard 95]. [1]

However, as Lakoff & Johnson observed in their seminal work, *Metaphors We Live By*, most metaphoric usage in everyday communication is *not* novel, but can be accounted for by a relatively small subset of regularly occurring metaphors, which they have termed *conceptual metaphors* [Lakoff & Johnson 80]. Subsequent empirical studies have given credence to this claim, with estimates of the total number of conceptual metaphors falling between 40-50 for a given domain [Martin 94]. Exactly which metaphors are most common tends to depend on both the domain (e.g. financial news vs. descriptions of emotions) and cultural influences.

The implication of this for computational systems is that constructing a knowledge base of common metaphors and their interpretations may suffice for the majority of metaphoric utterances that occur. As Carbonell aptly stated, "the problem of understanding a large class of metaphors may be reduced from a reconstruction to a recognition task" [Carbonell 82].

In fact, the most successful computational approaches to date have been so-called *knowledge-intensive* implementations which store explicit information about specific metaphors in a knowledge base, and supplement it with domain knowledge and information about the local discourse context [Martin 90, Barnden et al. 94, Narayanan 97]. However, by virtue of being knowledge-intensive, these systems have been limited to coverage of relatively few metaphors in narrow domains. Additionally, as Martin has criticized [Martin 94], most lack an empirical basis for the metaphors selected and do not make a serious effort to evaluate the performance of the final systems. In particular, it is not always clear what constitutes "interpretation" or what metrics should be used to compare the performance of one system against another. It is also not clear how well these systems generalize to handle new instances of a particular metaphor, particularly when these new instances contain syntactic and lexical variations.

This thesis addresses some of these shortcomings, building upon previous knowledge-based approaches to metaphor comprehension. While still limited to coverage of a narrow domain, it addresses some of the issues of establishing an empirical basis and suitable evaluation metrics for computational systems. Additionally, it advocates a *goal-driven* approach to metaphor comprehension, which assumes that each metaphor is selected by the speaker for its ability to satisfy a particular communicative goal. In the following chapters, we present the results of an empirical study of metaphors describing emotions and mental states, as found in a corpus of song lyrics, and describe PoEM (Parser of Emotion Metaphors), a prototype metaphor interpreter implemented using the results of this study. As PoEM demonstrates, the approach presented here provides a useful framework in which to think about metaphor and its underlying structure, as well as the subsequent analysis of computational systems for metaphor interpretation.

1.1 Why Emotion and Mental States?

The focus of this research is the relatively small but important subset of conceptual metaphors describing emotions and mental states. Included in this subset are the expression of feelings such as happiness, anger, sadness, and fear, and the expression of one's internal thoughts and associated processes. A few examples are:

I **see**. UNDERSTANDING-IS-SEEING

[1] Note this discussion considers only practical implementation issues. If one is to claim cognitive validity for a computational model, then one must also consider the results of empirical studies of metaphor processing.

I'm feeling really **down**.	HAPPY-IS-UP/SAD-IS-DOWN
This isn't **going anywhere**.	PROGRESS-IS-FORWARD-MOTION
I'm **lost**.	REASONING-IS-FOLLOWING-A-PATH; UNDERSTANDING-IS-ARRIVING

Note that it is not uncommon for utterances to include descriptions of *both* feelings and thoughts (e.g. *"I see your sorrow has blinded you"*). Consequently, although feeling and thought are generally regarded as distinct processes, for interpretation purposes it makes sense to consider both sets of metaphors together.

Because emotions and mental states are abstract, they are frequently described in metaphoric terms. One empirical study of metaphor usage for descriptions of emotion found that 13% of all "idea units" describing feelings were metaphoric (versus only 5% when describing actions associated with emotional events), and also noted a positive correlation between the intensity of feeling for positive emotions and metaphor frequency [Fainsilber & Ortony 87].

Thus, if we wish to model a person's mental or emotional state in computer applications involving communication with a human participant, it is important to understand the meaning of metaphoric sentences, for they may provide information critical to the success of the interaction between human and machine. Such applications include:

- linguistic interfaces for educational and medical diagnostic software
- expressive communicative media (e.g. automatic generation of temporal typography based on content analysis)
- story understanding and generation
- reasoning about beliefs and ideological point-of-view

1.2 Research Overview

The work presented in this thesis consists of two components: an empirical study, and a computational system.

The primary objective of the study was to provide a well-founded basis for implementing a computational system. To achieve this, an empirical analysis of the metaphor distribution in a corpus of song lyrics was conducted, focusing specifically on identifying the kinds of metaphors used to describe emotions and mental states, and how often these metaphors occur.[2] As will be shown, the study supports previous claims that the majority of metaphor occurrences are attributable to a relatively small subset of metaphors. Moreover, it provides useful data for modeling common syntactic forms that the metaphors assume.

The second portion of this research was the implementation and evaluation of a computational system for common conceptual metaphors of emotions and mental states. The result of this effort is a prototype called PoEM.

Although comprehension of common conceptual metaphors is significantly less difficult than comprehension of novel metaphors, it is still a challenging task. An interpreter must recognize different syntactic and lexical forms, as well as contain the knowledge necessary to interpret the metaphors correctly. For example *"they were in the middle of a heated argument"* and *"he had steam coming out of his ears"* both use the ANGER-AS-HEAT metaphor, but refer to different aspects of it (a direct reference to heat in the former, and an indirect reference to steam as an indicator of heat in the latter). To deal with these issues, PoEM capitalizes upon the results of the empirical

[2] Implicit throughout this thesis is the restriction to consideration of American English metaphor.

study in two ways. First, because most metaphor usage can be accounted for by a relatively small set of metaphors, maximum coverage for minimal knowledge-engineering can be achieved by focusing efforts on the most common metaphors. PoEM focuses on just the five most common metaphor groups, which collectively represent approximately 50% of all instances encountered. Second, PoEM adopts a *goal-driven* approach to identification and interpretation of conceptual metaphors, which relates the observed lexical and syntactic forms of a metaphor to the *communicative goal* of the speaker, that is, to a specific idea or piece of information which the speaker wishes to convey to the listener in the current context. The observed correspondence is translated into a set of *metaphor templates,* which combine pattern matching with semantic category restrictions on lexical and syntactic constituents to identify possible metaphors. Once identified, PoEM applies interpretation rules to construct the meaning of the utterance. As an additional simplification, PoEM is restricted to processing single-sentence input, thus avoiding the additional effort required to implement a discourse model.

PoEM has been evaluated using a set accuracy and coverage metrics on a set of metaphoric inputs. As expected, the results indicate that although unable to identify all possible syntactic variations of a metaphor in free text and not suitable for novel metaphors, this approach increases the likelihood that the system will know enough about those particular instances to make a meaningful interpretation. Essentially we trade off breadth of coverage for depth.

1.3 Contributions

The primary contributions of this thesis are:

- An extension of empirical knowledge about conceptual metaphors. The results of the empirical study identify specific metaphors and their frequency of occurrence in describing emotions and mental states. These results also provide additional support for theories that most metaphor usage is limited to a small set of conceptual metaphors
- An implementation and evaluation methodology for computational systems based on identification of common communicative functions served by conceptual metaphors.
- An implemented system which can be used in future research, either as a component within a larger NLP system, or as a tool for additional corpus-based analysis of metaphors.

1.4 Thesis Organization

The remainder of this thesis is organized as follows. Chapter 2 presents an overview of metaphor and a brief discussion of prior cognitive and computational research in metaphor comprehension. Chapter 3 describes the empirical study performed on a corpus of song lyrics, which serves as the basis for the PoEM system. Implementation details of the system are presented in Chapter 4, beginning with the design methodology and continuing on to the metaphor knowledge base, recognition templates, and interpretation rules. An evaluation of the performance of PoEM is presented in Chapter 5. Lastly, Chapter 6 closes with a short summary of the current work and a discussion of future research directions. Supplemental material described in the thesis has been included in Appendices A through C.

1.5 Thesis Notation

The following typographic conventions are used in this thesis:

- Descriptive names for conceptual metaphors are printed in capital letters

  SEEING-IS-UNDERSTANDING

- Input sentences are shown in quoted italics within the text or as an indented block in a different typeface

  "my surgeon was a butcher"

  My surgeon was a butcher.

- Metaphoric usage is in boldface

  *"I **lost** my love."*

- Semantic relations are capitalized and italicized

  ISA or *PART-OF*

- Source code and psuedo-code examples are printed in courier

  `(equal ?agent person)`

2 Background

This chapter presents the background material necessary to understand the current work and place it in context of prior research in metaphor comprehension. It begins by addressing fundamental questions about the nature of metaphor: What are the characteristics which define a metaphor? What distinguishes metaphor from other forms of figurative language as well as from literal language? When is metaphor used? In particular, we focus on how metaphor utilizes a *systematic mapping* between source and target concepts, and how this mapping can be related to communicative intent. We also describe the idea of *conceptual metaphor* [Lakoff & Johnson 80] on which the current work is based.

With this foundation established, one can then consider the more challenging question of how metaphors are understood. The most influential cognitive theories are briefly discussed in light of current empirical evidence. We then review prior computational systems for metaphor comprehension. Emphasis is placed on recent implementations and knowledge-based approaches most similar to the current research. Short descriptions of two metaphor databases of interest to both computational and cognitive research are also included. Finally, the chapter closes with a summary of the major points presented and their relationship to the current work.

2.1 What is Metaphor?

Metaphor is generally defined as the use of a familiar concept (the *source* or *vehicle*) to describe or explain another less familiar one (the *target* or *topic*)[3]. As an illustration, consider the metaphoric utterance:

Our relationship is **going nowhere**

Characteristics of a *journey* (i.e. that it has a destination, with progress measured as a function of distance from this destination) are used to describe aspects of the more abstract concept *relationship*. We infer that if a relationship is *"going nowhere"* then no progress is being made and it is not likely that the relationship will continue.

A key characteristic of metaphor is the systematic mapping of relations between the source and target concepts [Lakoff & Johnson 80; Gentner 83; Tourangeau & Sternberg 82]. As shown in Figure 2.1 for the RELATIONSHIP-IS-A-JOURNEY metaphor, not only are the notions of a destination and progress mapped via analogy, we also find analogues for other related concepts such as a *means of transport* (the relationship itself), *obstacles* (conflicts in the relationship), and a *path* (series of events in time). Moreover, this mapping extends beyond adopting terminology; it establishes a framework of knowledge in which to think about the target concept: in this case, how to reason about

[3] Over the years, researchers have used several different terms to identify the constituents of a metaphor. This work adopts the terminology *source* and *target*.

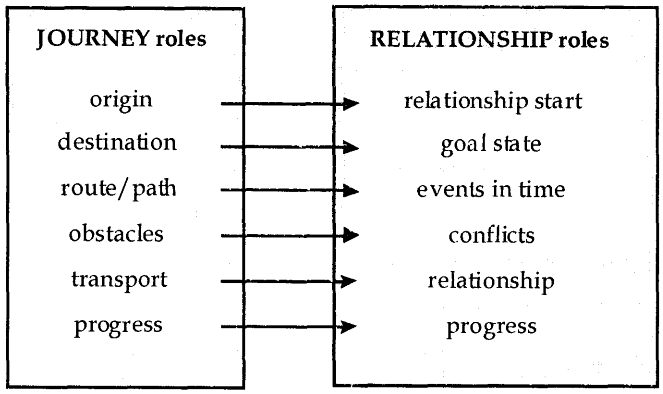

Figure 2.1 Metaphoric mapping between *journey* and *relationship.*

and describe the state of a relationship.

As a consequence of establishing this framework, metaphors are frequently *generative* [Lakoff & Johnson 80]. By understanding that a relationship can be structured in terms of a journey, we can then describe different aspects of relationships such as conflicts using statements like:

let's **start over** again
nothing is going to **stand in our way**
what can we do to get things **back on track**?

Metaphor mapping tends to *highlight* and *hide* various aspects of the target concept [Black 79; Lakoff & Johnson 80]. For example, the RELATIONSHIP-IS-A-JOURNEY metaphor emphasizes the notion of measuring progress in a relationship, but offers no guidance about how this progress is best achieved. We also conveniently ignore the fact that in the relationship analog, we are measuring the distance to an abstract destination, unlike a journey, which typically has a concrete end point. Additionally, note that metaphor is only a partial mapping; not *all* features of the source have analogs in the target. In the current example, specific journey characteristics (e.g. activities such as sightseeing) are ignored.

Finally, metaphor often exhibits *asymmetry*, in that it is a predominantly unidirectional transfer of meaning from the source to the target [Tversky 77; Ortony 79][4]. If the source and target concepts are swapped, both the mapping and emphasis will change. Consider the metaphor *"my surgeon was a butcher"*. The meaning of this metaphor is quite different from its converse *"my butcher was a surgeon"*. Although you are still essentially comparing skills, the expected skill level changes dramatically (from crude in the first case, to highly precise in the second).

These characteristics have important implications for computational systems. A successful system must be capable of handling the range of lexical and syntactic constructions possible for each metaphor. It must model the entire system of features which are mapped between the domains, and not just provide a single link between individual source and target concepts. Moreover, each of these links must be directed. It must also include a mechanism for distinguishing between features that should be mapped and those that should not. Additionally, because metaphors highlight and

[4] Although others (c.f. [Black 79; Tourangeau & Sternberg 82; Turner & Fauconnier 95]) have argued that metaphor alters a person's perception of both source and target concepts.

hide different aspects of a concept, choice of metaphor may indicate an implicit viewpoint or intention on the part of the speaker, which may be important to capture.

2.1.1 Types of Metaphor

Although all metaphor utilizes some type of analogical mapping between a source concept and a target concept, individual metaphors vary widely in how familiar they are to the speaker and listener, and how complex their linguistic structure is. Some metaphors are extremely common, to the point where we have difficulty recognizing them as metaphors. At the other end of the spectrum are novel metaphors like those typically used in poetry or literature. A metaphor may consist of an individual word or phrase, an entire sentence, it may be constructed over the course of a paragraph, or even extend throughout an entire story. Further complicating matters, a metaphor may make explicit mention of both source and target concepts, or it may rely on knowledge of the surrounding context or related concepts to infer either. Metaphors may also be formed from multiple sources or consist of two or more metaphors used together. These dimensions are summarized pictorially in Figure 2.2.

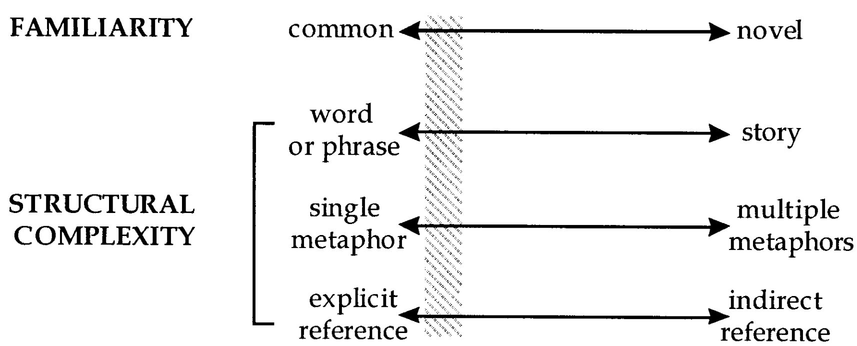

Figure 2.2 Dimensions of metaphor. Metaphor varies widely in both familiarity and structural complexity. The shaded region represents the range addressed by the current research.

From a computational perspective, the effort required to recognize and understand different metaphors varies considerably. A metaphor that is familiar might be handled by simple retrieval and application of the appropriate analogy from memory, while a novel metaphor entails identifying and constructing a relevant analogy. Longer metaphors and metaphors which make implicit or indirect reference to source and target concepts require greater knowledge of linguistic structure, history of prior events and current context, and access to "common sense". Systems of metaphors constructed from two or more metaphors require the ability to unify the various analogies into a consistent whole.

In the current work, only the left end of the metaphor spectrum is considered: single, common metaphors constrained to the phrase or sentence level, with explicit mention of the target concept.

2.1.2 Other Forms of Figurative Language

Metaphor is just one of several phenomena which fall under the classification of non-literal or *figurative* expressions (also referred to as *tropes*). Other types of figurative expressions include idioms, proverbs, indirect speech acts, and metonymy, each of which is briefly defined below.

Idioms - An idiom is a phrase with relatively fixed wording and syntax whose meaning cannot be determined by looking at the meaning of the individual words. Of the different figurative expressions, idiom is the one most similar to metaphor. Examples of American English idioms include, *"bad-mouth"*, *"hit the sack"*, *"by and large"*, *"pull out all the stops"*, and *"on the cutting edge"*.

Proverbs - Proverbs are succinct sayings highlighting common beliefs or observations, often expressed metaphorically. Examples of American English proverbs: *"A bird in the hand is worth two in the bush"*, *"Good things come in small packages"*, and *"Two wrongs don't make a right"*.

Metonymy - Metonymy is the use of reference to a part to signify the whole (also referred to as synecdoche). Examples include *"The White House announced..."* and *"Table 5 wants his check"*.

Indirect Speech Acts - Indirect speech acts include polite requests such as *"Can you close the window?"* uttered when a nearby window is open, and irony. Generally, correct interpretation depends upon knowledge of the current context and familiarity with conversational conventions (cf. conversational implicature [Grice 89]).

The characteristic shared by all of these expressions is *non-compositionality*. That is, the meaning for each cannot be determined solely from the meanings of its constituent words and phrases. Correct interpretation depends upon additional knowledge such as familiarity with a particular domain, societal conventions, or the context in which the utterance occurs [Lakoff & Johnson 80; Katz 96].

The present work deals only with metaphor. However, these other forms frequently co-occur with metaphor, and at times it can be difficult to distinguish between one and the other (particularly in the case of idiom).

2.2 When is metaphor used?

Hypotheses about metaphor usage generally fall into two categories: those which emphasize metaphor's cognitive role, and those which focus on metaphor's communicative functions. Considering that thought and communication are complementary processes, these hypotheses need not be considered mutually exclusive; it is probable that metaphor serves both roles.

2.2.1 Conceptual Structuring

One popular view of metaphor usage is that metaphor is an integral component of our conceptual system [Lakoff & Johnson 80]. In the previous section, we described how metaphors are frequently generative, providing a framework in which to reason about the target concept. Lakoff & Johnson's hypothesis takes this idea one step further, claiming that we are grounded in our direct experience of the world and use metaphor to understand more abstract ideas in terms of this experience. In their view, we don't just use a metaphor like TIME-IS-MONEY; we actually conceptualize and understand time through our experience with physical resources. Most metaphoric usage is thus attributable to *conceptual metaphors*, or instances of metaphorically structured concepts like these[5]. Informal support for this claim is given by the generative nature and numerous examples of everyday metaphors derived from physical experience, particularly experience with physical space and our bodies.

2.2.2 Communicative Functions

Other hypotheses claim metaphor is used primarily to satisfy specific communicative needs of the speaker. The three most common of these are (adapted from [Fainsilber & Ortony 87]):

Inexpressibility - Metaphors are used to express ideas that are difficult to communicate with literal language.

Compactness - Unlike literal language, which is composed of discrete information units, metaphors communicate larger "chunks" of information. Thus, metaphoric utterances can represent and communicate ideas more efficiently than literal language.

Vividness - By appealing to sensory and perceptual inputs, metaphors help capture and express the "vividness" of our subjective experiences. This has also been referred to as the *emotional force* or *resonance* of metaphor.

2.3 What makes a good metaphor?

There are two common views about how concepts and feature mappings are selected in a metaphor. The first view is that the concept should be a prototypical member of its class, or similarly, that it should possess highly salient features which are relevant to the current topic (c.f. [Ortony 79; Glucksberg & Keysar 90]). For example, a giraffe is more likely to be a source for metaphors about *height* than it is for metaphors about *speed*.

The second view is that metaphors tend to preserve higher-order, or more abstract relations between features of the source and target concepts, and frequently preserve entire systems of relations [Tourangeau & Sternberg 82; Gentner 83; Holyoak & Thagard 95]. Unfortunately, given that a concept possesses a very large number of features, and that feature importance depends on the current context, it is still difficult to determine which relations to consider first.

One interesting set of heuristics proposed to direct the relation search is Carbonell's invariance hierarchy of mapping types [Carbonell 82], presented in Table 2.1. This hierarchy is a start towards making an explicit connection between speaker intent and the types of relations used to convey that intent, and can provide a useful first cut at considering context. For example, if the current topic of discussion one's thought process, then it may be useful to look first for features describing planning strategies, temporal order, or structural relations.

2.4 How Are Metaphors Understood?

Despite many years of studying metaphor and other forms of figurative language, we

[5] Also referred to by some as *conventional metaphors*.

Table 2.1 Carbonell's invariance hierarchy for metaphor mapping. Categories are listed in order of decreasing invariance from source to target (adapted from [Carbonell 82]).

Mapping	Description
GOALS	Goals of animate characters in the source domain are attributed to analogous characters (or personified objects) in the target domain. For example, in a **journey** the traveler's goal is to reach the destination. This goal is carried over to the domain of **relationships** as the goal to progress towards the end state (ongoing happiness).
PLANNING STRATEGIES	Strategies and priorities amongst multiple goals are preserved, providing insight as to how one may go about satisfying goals in the target domain. For example, the metaphor ARGUMENT-IS-WAR introduces ideas of attack and counterattack, with victory as the objective.
CAUSAL STRUCTURE	Explicit causal structure from the source is often carried over to the target. For example, opening a **container** will make its contents accessible; analogously, to have access to a **person**'s feelings, you must get them to *"open up"*.
FUNCTIONAL ATTRIBUTES	Functional attributes of the concept in the source domain will be applied to an analogous function in the target. For example, a **container** can be used to enclose and protect an object; likewise a **person** can *"conceal"* and *"protect"* their feelings from others.
TEMPORAL ORDER	Temporal sequences of plans in the source are applied to the target. For example, in the metaphor EXPERIENCING-IS-INGESTING, we retain the temporal ordering of *"chewing"* followed by *"swallowing"* and *"digestion"* in describing different stages of experience.
NATURAL TENDENCIES	Expected general behaviors of components in the source are applied analogously to components of the target domain. For example, in the analogy between electric circuits and water flow in pipes, we think of thin wires resisting the flow of electrons, much as a narrow pipe restricts water flow.
SOCIAL ROLES	Social roles played by constituents are sometimes preserved and sometimes ignored. For example, in the metaphor LOVE-AS-ILLNESS, the person experiencing love is the patient, an essentially passive role in which they wait for an external cure. In contrast, the ARGUMENT-IS-WAR metaphor does not preserve specific war roles such as battleship commander.
STRUCTURAL RELATIONS	Structural relations between constituents are occasionally preserved. Often, however, they are transformed or ignored, such as in the classic solar system analogy of the atom maintaining the orbit relationship. In ARGUMENT-IS-A-STRUCTURE you maintain a support relation, but ignore others such as adjacency.
DESCRIPTIVE PROPERTIES (object attributes)	Attributes are seldom preserved. For example, ARGUMENT-IS-A-STRUCTURE may refer to material composition as a means of describing structural integrity (i.e. *"I see cracks in your argument"*), but ignores other physical characteristics such as color and physical dimensions.
OBJECT IDENTITY	Objects in the source domain are almost never carried over to the target without modification. Usually, references to objects are mapped to some analogous component in the target.

still know very little about the cognitive processes underlying their production and comprehension. This section presents a brief overview of the more popular cognitive theories proposed over the last thirty years, along with a summary of empirical evidence which supports (and in some cases contradicts) them. As will be seen, many of these theories generally lack the level of detail required to construct a computational system, yet they nonetheless highlight important characteristics of the interpretation process that must be addressed by computational systems.

Because the current objective is to identify characteristics thought to be critical to the interpretation process, many of the variations and subtleties of the individual theories have been omitted. Likewise, details of the empirical studies are not discussed. For additional information the reader is referred to [Ortony 93; Honeck 96; Katz 96].

2.4.1 Theories of Metaphor Comprehension

Most cognitive theories adopt variations of one or more of four basic processing models: metaphor as a comparison, metaphor as a process of interaction, metaphor as categorization and metaphor as an anomaly.

Metaphor As Comparison

As the name suggests, comparison theories view metaphor interpretation as the identification of similarities between source and target concepts through some form of comparison. The general emphasis of these theories is on explaining how relevant *predicates* (attributes, beliefs, and other knowledge) are selected and mapped between the source and target during the comparison process. Typically, these explanations have taken the form of predicate-selection rules.

The *salience imbalance* theory considers use of salience imbalance between the source and target predicates to be key in metaphor interpretation [Tversky 77; Ortony 79]. Salient predicates of the source concept are applied to a target in which these characteristics are either of low salience or are absent (e.g. *"encyclopedias are gold mines"*). The result is the introduction or emphasis of these predicates in the target. In contrast, literal interpretation of similarity statements often compares predicates which exhibit high salience in both the source and target concepts (e.g. *"encyclopedias are like dictionaries"*). However, this theory has been criticized on the basis that a salience imbalance alone does not adequately account for our ability to distinguish between metaphoric and literal usage (c.f. [Glucksberg & Keysar 90]), as literal statements may also exhibit an imbalance as well.

Other comparison-based theories such as *structure mapping* [Gentner 83] and the *multi-constraint theory* [Holyoak & Thagard 95] construct analogies between the source and target concepts using rules to select the predicate mapping. In structure mapping, analogies based on object *relations* (e.g. LARGER_THAN(x,y)) are preferred over those based on attributes of individual objects (e.g. RED(x)), and analogies which map entire *systems* of relations in a consistent manner (the *systematicity principle*) are given highest preference of all. The multi-constraint theory of analogy is quite similar in that it also considers identifying higher-order relations and systems of relations to be important constraints for interpreting an analogy. One point on which the two differ, however, is that multi-constraint theory also explicitly considers purpose. That is, important relations are those relevant to the communicative goals which lead to selecting a particular analogy.

Although all of these comparison theories recognize that the salience or importance of predicates and relations are context-dependent, only the multi-constraint theory explicitly incorporates some notion of context (as the purpose constraint) into the interpretation process; all others pre-suppose a mechanism which handles this context-dependency. However, this is itself a challenging task.

A related shortcoming is that these theories tend to consider metaphor outside the syntactic framework in which it occurs. Most focus on simple nominal comparisons of the form *A is B*, and do not discuss how well these ideas translate to other metaphoric constructions, or consider whether syntactic structure may provide useful information during interpretation.

Metaphor As Categorization

The *class-inclusion* model considers metaphor comprehension to be a *categorization* process [Glucksberg & Keyser 90]. A prototypical source concept representing an entire category is used to classify the target concept as a member of that category. For example, *"my job is a jail"* utilizes *"jail"* as a prototypical representation of the category *confining things* and introduces the target *"job"* as a member of this category. Unlike the comparison models, similarity is seen as an effect of the categorization rather than the key to comprehension.

However, much like the comparison models, the class-inclusion theory essentially hinges upon identification of an aptness metric, this time a measure of prototypicality, rather than predicate salience.[6] And once again, while context is recognized as key to the selection process, how this should be incorporated into the model is left largely unanswered.

Metaphor As Interaction

Another popular model of metaphor comprehension is the *interaction theory* of metaphor [Black 79]. The interaction model shares many characteristics of the comparison models, but also incorporates the notion of an *interaction* between the source and target concepts resulting in changes to the perception of both concepts. Like the theories based on analogy, the interaction model considers the mapping of systems of relationships between predicates in the source and target. In the source, this system of relationships is called the *implicative complex.* Metaphor interpretation projects this implicative complex onto the target, resulting in emphasis, suppression, and structuring of characteristics of the target based on the source. Moreover, the target in turn induces changes in the source subject in the minds of both speaker and listener. Unfortunately, the theory does not define exactly how the mapping and subsequent interaction is carried out.

Tourangeau and Sternberg provide a more concrete extension of these ideas in the *domains interaction* theory. Their proposed interpretation process begins with identifying the appropriate concept domains, where a domain is the *natural category* or some highly salient class to which the concept belongs. Once identified, the feature structures of each domain which form the analogy are identified and mapped using the following set of relations: feature abstraction, natural correlation (statistical co-occurrence), shared labels, mapping to a common absolute scale (such as height), relation via a common third domain, or finding shared semantic network structures [Tourangeau & Sternberg 82]. Additionally, the domains-interaction theory proposes that the likelihood of a particular interpretation can be estimated by *within-domain* similarity (a euclidian measure of the correlation between higher-order features of the concept domains) and *between-domain* distance (a measure of the dissimilarity of the

[6] In fact, one could arguably call this a comparison theory: if the categories of the class-inclusion model are redefined as predicates (i.e. redefining 'confining things' from a category to the predicate 'is-confining'), the class inclusion model looks much like the comparison models discussed previously.

concept domains themselves). Metaphors using concepts from domains with a high within-domain similarity and large between-domain distance are judged more likely or apt. Note that although the domains-interaction theory does provide some heuristics for identifying possible features and a concrete measure of metaphor likelihood, it assumes a mechanism to identify the appropriate domains given a particular context.

A recent theory combining the ideas of Lakoff's conceptual metaphor and interaction theory is the *many-space* model [Turner & Fauconnier 95; Fauconnier 97]. Separate source and target *mental spaces* are linked by a generic space containing features common to both, and a fourth blended space which extends the partial mapping of the generic space to create the final concept. This process of *conceptual blending* utilizes cross-space mapping of input counterparts, and integrates events into a single unit, giving rise to new structure that is not present in either of the input concepts. For example, the expression *"digging one's own grave"* borrows ideas of death, grave-digging, and burial from the source domain, but the resulting interpretation of *"inadvertently doing things which will lead to one's own failure"* contains ideas not present in the source. These include inversion of the causal structure, such that the act of digging the grave results in death (and not the other way around), and introduction of a correlation between grave depth and risk of failure. This model is notable for its consideration of much more sophisticated metaphor constructions than most other theories, but the conceptual blending process currently lacks too many details to be of practical use.

Metaphor as Anomaly

Perhaps the most contested model of metaphor comprehension is that of metaphor as an anomaly. Introduced by Searle's *standard pragmatic model* [Searle 79], and extended in *preference semantics* [Wilks 78], the anomaly view postulates that we attempt a literal interpretation first, and upon encountering a "failure", re-interpret the utterance figuratively. This failure occurs when there is an inconsistency in the semantic information or role restrictions of the target and those given by the source. For example, literal interpretation of *"my grandfather is a baby"* fails because the ages associated with concepts *"grandfather"* and *"baby"* are inconsistent. Once a failure is identified, then the likely figurative meaning must be computed (which can be seen as the starting point for the other models). Thus in the anomaly view, literal processing always occurs prior to metaphoric interpretation.

The anomaly model has been criticized on several points. First, the preference for a literal interpretation suggests that metaphor processing is an additional process added after literal processing. Second, whenever a metaphor occurs, a failed literal interpretation of the expression can also be found. As will be discussed in the next section, neither of these claims have been supported by psycholinguistic results. The anomaly view also cannot account for metaphors which make use of a literally true utterance. For example, the metaphor *"no man is an island"* is also literally true.

2.4.2 Psycholinguistic Evidence

Since we cannot directly observe the comprehension process, we must rely on experiments which provide indirect evidence for various hypotheses. A common approach is memory-based testing in which a subject is asked to recall previous information or judge new data. Typically these tests are used to assess stored knowledge about figurative language use, and as an indirect indicator of the processes used during comprehension. Another common technique is on-line testing which assumes limited availability of cognitive resources, and a correlation between processing time and task difficulty. Latency measures such as reading time, eye movement, and reaction time are used to track processing as it occurs. The most significant findings of various studies can be summarized as follows (adapted from [Katz 96]):

- *Comprehension time is often comparable for both literal and metaphoric statements* - Given sufficient context, metaphors are comprehended as quickly as literal statements. While this neither proves nor disproves the theory that metaphor comprehension is a process distinct from literal comprehension, it does provide evidence that metaphor interpretation is not something that must always follow literal processing mechanisms, counter to the anomaly view of metaphor.
- *Literal interpretation may have priority when the statement is unfamiliar* - Some studies have demonstrated that for unfamiliar metaphors, literal processing also occurs.
- *Context is important* - Different contextual conditions may lead to preference for a particular interpretation, either metaphoric or literal, and sometimes both simultaneously.
- *Metaphor influences perception of both source and target* - Creating metaphors creates similarity between concepts and may influence processing time for related words from the same conceptual domains.

2.5 Computational Approaches To Metaphor Comprehension

A number of computational models for metaphor identification and interpretation have been proposed, but only a subset have been implemented. Some of the more influential approaches (with emphasis on more recent work) are summarized in Table 2.2. Note that this list is representative of the various approaches which have been taken, but is not exhaustive.

Implementation details vary widely, but most models generally include a knowledge base consisting of domain knowledge and sometimes knowledge of specific metaphors, and a computational method for processing metaphor, either incorporated into the general processing scheme, or handled by special routines. Until recently, all approaches were symbolic, frequently using semantic networks to represent domain knowledge [Falkenhainer et al. 86; Martin 90; Fass 91] and analogical reasoning techniques (c.f. [Gentner 83]) to map constituent relations between the source and target domains. However, as metaphor complexity and network size increase, symbolic systems which construct analogies at run time suffer, as the potential number of mappings which must be considered is exponential in the number of nodes. These drawbacks have motivated recent hybrid connectionist approaches such as CONSYDERR [Sun 95] and Sapper [Veale & Keane 95]. Unfortunately such hybrid systems have been implemented and tested only on small examples; it is not clear how well they will scale to larger problems.

The most successful implementations for metaphor comprehension have been those which incorporate explicit knowledge of metaphors (cf. [Martin 90; Barnden et al. 94; Narayanan 97]). By pre-encoding links between source and target concepts, potentially expensive analogical matching is avoided. The main disadvantages to the knowledge-intensive approach is the additional work required to explicitly encode the knowledge, and the difficulty of getting the representation correct (since what works in one situation may not be sufficiently general to handle the next).

The MIDAS/MES system [Martin 90] was a UNIX help system capable of answering both literal and non-literal queries. Sets of associations specifying the metaphoric mapping between source and target concepts were explicitly encoded in the knowledge base (40 metaphors in all). Given an input statement, MIDAS would return all possible interpretations (both literal and metaphoric) which satisfied the semantic constraints of the statement. MIDAS could also learn new metaphors by extending analogies for existing metaphors. However the system could not learn metaphors which were either completely novel (i.e. there was no existing source metaphor similar enough to extend), or which consisted of two or more conceptual metaphors. Martin provides examples of sentences that the system was able to process correctly, as well as examples where it was able to learn a related metaphor, but does not present an evaluation of overall system performance.

KARMA [Narayanan 97] interpreted short news stories about international economic policy, using explicitly encoded knowledge of metaphors relating abstract domains to spatial terms and events (also known as the Event Structure system [Lakoff et al. 91]). The main contribution of KARMA was the ability to perform simulative inference across multiple time steps (up to five, represented in a temporally extended belief network) and spatial domain knowledge to update knowledge about economic policy. For example, given input such as *"Indian Government stumbling in implementing Liberalization Policy"*, KARMA would use knowledge of spatial relations to infer that *"stumbling"* caused instability, and depending on available resources, could lead to a fall. Narayanan also tracked speaker intent based on the metaphor used. The system contained approximately 50 metaphor maps, and was tested on approximately 30 two- and three-line excerpts from news stories.

ATT-Meta was built not for metaphor interpretation, but for reasoning about mental states [Barnden et al. 94]. Like KARMA, ATT-Meta uses knowledge about metaphors to

Table 2.2 Summary of previous computational models for metaphor comprehension.

Model	Impl?	Domain	Cognitive Theory	Architecture	Interpretation Technique
Structure Mapping Engine [Gentner 83, Falkenhainer et al. 86]	yes	Physical science analogies (heat - fluid, atom - solar system)	Comparison Theory	symbolic	Analogical matching of concepts based on "systematicity principle" which gives preference to interpretations mapping higher order relations between concepts. Rules assign likelihood measures for potential matches.
ACME & ARCS [Holyoak & Thagard 95]	yes		Comparison Theory	symbolic	Analogy system which uses parallel constraint satisfaction to implement their 'multi-constraint theory' of interpretation, satisfying constraints of similarity, structure, and purpose.
Approximate Semantic Transference [Indurkhya 87]	no	NA	Interaction Theory	symbolic (formal logic)	AT-MAP analogical mapping between source & target
CONSYDERR [Sun 95]	yes (small example)	Sentences of the form *"X is Y"*	Interaction Theory	hybrid connectionist	Uses a localist concept layer plus a distributed microfeatures layer. Also proposes use of context nodes. No training times or performance statistics provided. Implemented for small example.
Sapper [Veale & Keane 95]	yes	Analogies between occupation descriptions (15 total)	Interaction Theory	hybrid connectionist	Uses local nodes and arcs to represent concepts and semantic relations, and a connectionist component to activate dormant 'bridges' between concepts. Uses systematicity to select best interpretation.

Table 2.2 Summary of previous computational models for metaphor comprehension (continued)

Model	Impl?	Domain	Cognitive Theory	Architecture	Interpretation Technique
Meta5, Met* [Fass 91]	yes	Applied to small number of sentences; limited syntax	Preference Semantics	symbolic (semantic vectors)	Identifies metaphor as preference violation. Performs analogical match by relaxing selection restrictions on semantic roles.
POLITICS [Carbonell 82]	partial	NA	Conceptual metaphor + Preference Semantics	symbolic	If literal interpretation fails, interpret as metaphor. Proposed using knowledge of common conceptual metaphor plus analogical mapping. Gave preference to interpretations with goal and plan invariance. Also noted speaker intent based on metaphor choice.
MIDAS [Martin 90]	yes	UNIX help system; 22 metaphors + 18 UNIX-specific metaphors	Conceptual metaphor	symbolic (KODIAK)	Knowledge base lookup & comparison of semantic constraints. Limited handling of new metaphors via analogy to known related metaphors.
LINK [Lytinen et al. 92]	yes	NA	Conceptual metaphor	symbolic (unification grammar)	Combined syntactic and semantic parse. Incrementally constructs both literal and metaphoric mappings.
ATT-Meta [Barnden et al 94]	yes	Belief reasoning	Conceptual metaphor	symbolic	Applies simulative reasoning about mental states using 4 common mental state conceptual metaphors.
KARMA [Narayanan 97]	yes	Economic Policy; up to 3 sentences of input; 50 metaphors	Conceptual metaphor	symbolic	Metaphor maps explicitly encode common spatial metaphors. Uses spatial domain knowledge for simulative inference about the target domain. Also tries to infer speaker intent.

make inferences about the target domain, the belief structure of the speaker. ATT-Meta focused on four conceptual metaphors: MIND-IS-A-CONTAINER, IDEAS-ARE-MODELS, IDEAS-ARE-INTERNAL-UTTERANCES, and MIND-PARTS-AS-PERSONS. No performance information was provided for the system.

2.6 Metaphor Databases for English

The Berkeley Metaphor Project is an ongoing effort to compile and organize a comprehensive list of common conceptual metaphors [Lakoff et al. 91]. This list has been compiled by hand from published metaphor literature and individual contributions. Currently, it is organized into four categories: the Event Structure system, mental events, emotions, and "other". Within each category, descriptions and examples are provided for individual metaphors. Although some effort has been made to organize the material into sub-categories, more work remains. Lakoff also indicates that overall, the list represents only an estimated 20 percent of the material they have accumulated.

The Metabank project is another effort which aims to construct a knowledge-base of English metaphoric and metonymic conventions based on empirical analysis of text corpora for various domains (currently Unix help systems and news articles from the Wall Street Journal) [Martin 94]. This project is motivated by observations that detailed empirical analysis is necessary to confirm metaphor knowledge-base accuracy and coverage. Although previous empirical studies measured overall metaphor frequency [Pollio et al. 90], they do not contain individual metaphors or their distributions. Martin proposed constructing Metabank using a combination of search (using word sets generated from the Berkeley Metaphor List) and random sampling techniques to determine frequency statistics, identify new metaphors, and verify metaphor representations. Currently Metabank includes metaphor information derived from a study of Wall Street Journal articles[7]. To my knowledge coverage has not yet been extended to include other domains.

2.7 Summary

This chapter has presented a number of important characteristics of metaphor that must be considered by computational systems for metaphor comprehension. In the general case, systems that interpret novel metaphor should include:

- A *representation scheme* for concepts and relations between concepts
- A *transformation process* from the lexical and syntactic structures to their underlying concepts. This entails mechanisms for identifying the concept categories to which the lexical items belong, and for parsing and extracting information from various syntactic structures.
- A *feature and relation identification process* which identifies the source and target relations important to the current analogy and takes context into account
- A *mapping process* which creates correspondences between the source and target, validates the consistency of the transferred meaning, and possibly infers or creates new meaning structure.
- An appropriate *output representation*, given that a literal paraphrase is frequently inadequate.

Only a few analogy-based systems have actually attempted to handle novel metaphor interpretation. However, the knowledge and search requirements of the problem have made it impractical to consider any large-scale implementations using these approaches. Identifying better ways of managing the computational complexity continues to be an important area of research, especially studying ways in which contextual information can help.

In addition to the effect of context on salience or prototypicality, a related topic which has not been well-studied is the relationship between metaphor and its communicative functions. We still do not understand if or what kind of correlation exists between communicative intent and choice of metaphor. Fortunately, with the increasing availability of electronic corpora, studies of both contextual effects and communicative function are now much more feasible.

Yet another issue which has been inadequately addressed is the relationship between lexical and syntactic form of a metaphor and interpretation. Because most theorists have analyzed metaphor outside the language structure in which it occurs, it is difficult to predict how well these theories generalize to metaphor constructions beyond simple "*A is B*" comparisons.

Thus it is not surprising that prior computational systems with the largest coverage of metaphor have been those which focus on common conceptual metaphors. Here, the source and target concepts have already been identified, and we may make use of

[7] Based on analysis of approximately 600 randomly selected sentences.

empirical data from databases like the Berkeley Metaphor List and Metabank to identify the types of features or relations which are important to the metaphor. Of course, we still must deal with the challenges presented by context, communicative function, and the relationship between syntactic structure and underlying meaning, but this is exactly where we *should* be focusing current research efforts.

The approach taken in the current work can be viewed as a preliminary step towards addressing some of these issues. The next chapter, presents results of a corpus study which show some evidence that form and function are related, and that this relationship can be used advantageously in computational systems. Moreover, this work builds on the previous knowledge-based approaches by making use of empirical analysis to provide a more well-motivated basis for implementation than in previous systems.

It should be noted that as input has been limited to single sentences, contextual effects are not considered by this research. And unlike many previous computational implementations, the present approach makes no claims of cognitive validity.

3 Metaphoric Descriptions of Emotion: An Empirical Study

As previously noted, it is critical to understand how we actually use metaphors prior to implementing a knowledge-based system for metaphor comprehension. How frequently do metaphors occur in natural language? What kinds of metaphors do we use? How does this usage vary between domains? Answering these questions serves two purposes. First it confirms (or disproves) the underlying assumption of the knowledge-based approach: namely, that a relatively small number of conceptual metaphors account for the majority of metaphor occurrences in the domain of interest. Second, given the initial assumption is confirmed, answering these questions details which metaphors are most prevalent and what kinds of cross-domain mappings they rely on.

This chapter presents the results for an empirical analysis of a corpus of song lyrics. Following the approach introduced in Metabank [Martin 94], two types of studies were performed on the corpus: hand-sampling and directed search. Hand-sampling of a small subset was used to evaluate the utility of the corpus, and to confirm the feasibility of the knowledge-based approach by determining rough estimates of the types and occurrence rates for metaphoric emotion and mental state descriptions. Once the most common metaphors were identified, a directed-search for the top five metaphors was performed on a larger subset of the corpus using keywords. The objective of this task was to gather additional information about these metaphors for use in constructing the knowledge-base, recognition, and interpretation routines of the metaphor comprehension system.

3.1 The Lyrics Corpus

First of all, why study song lyrics? Since the goal of this research was to construct a computational system for the comprehension of emotion metaphors, it was necessary to find a domain which contained a significant number of references to emotion. Additionally, practical constraints limited consideration to data available in large quantities, readily found in electronic form, and which used relatively simple language. Given these requirements, song lyrics were an obvious choice (thanks largely to the existence of the World Wide Web and many music enthusiasts).

The corpus was constructed from data found on lyrics servers (large collections of voluntary contributions), personal web pages, and commercial web sites for individual artists and record labels. Lyrics representing a broad range of music styles were selected to ensure that possible variations in metaphor distributions caused by individual artists' preferences and music genres were considered.

During compilation, four "genres" were targeted: alternative, country, blues, and soft rock/easy listening. Within each genre, lyrics were assembled from at least 10 different artists, and where possible, at least 10 songs from each artist were used. Decisions about the specific artists and songs included were made primarily as a function of lyrics availability, and somewhat influenced by personal experience

```
**********************
@id 246
@genre easy listening
@title "Keep The Fire Burnin"
@artist "REO Speedwagon"
@source "http://www.lyrics.ch/search.html"

Keep the fire burnin'
Let it keep us warm
The world will keep on turnin'
Let it turn you on
Let us not stop learnin'
We can help one another be strong
Let us never lose our yearnin'
To keep the fire burnin' all night long

You've been changing so much
I'm not sure your in touch with what's real
You just come and you go
Never letting me know how you feel
And I'm livin here in doubt
There's so much to talk about
I know that we can work it out

We've been through this enough
It gets rough but there's nowhere to run
This is where we belong
We are strong, we can never give up
If we wanted to we could
But we've always understood
To keep lookin' for the good

**********************
@id 247
@genre easy listening
@title "Sweet Time"
@artist "REO Speedwagon"
@source "http://www.lyrics.ch/search.html"

When I awaken, feelin' no pain
Visibly shaken, waitin' to touch you again
My temperature's risin, but I'm fallin' a bit behind
And that ain't so surprising, were gonna take our own sweet
time
```

Figure 3.1 Sample lyrics entries.

(personal stereotyping of artists). In the initial collection stage, content was not considered at all (aside from confirming it was English).

The raw data was then reviewed and hand-edited to produce the final corpus. Leading white-space, tablature, parenthetical information (e.g. *"(drum solo)"*, *"REPEAT 3X"*, *"CHORUS:"*) and sequences of non-words (e.g. *"Woo woo!"*, *"Ahhhhh"*) were removed. Additionally, all songs which lacked regular sentence structure or were difficult to understand were eliminated. In some cases, all songs of a particular artist were eliminated, and more data collected.

The final corpus is an ASCII text file, an excerpt of which is shown in Figure 3.1. Headers inserted at the beginning of each song include an identification number, genre, the song title, artist's name, and source. In all, the corpus contains 624 songs (119,583 words) representing 50 artists. A summary of the corpus contents by genre is provided in Table 3.1. A more detailed breakdown by artist is included in Appendix A.

Table 3.1 Composition of the lyrics corpus by genre.

Genre	Artists	Songs	Words
Blues	15	149	25,186
Country	12	174	34,339
Alternative	10	126	24,413
Soft Rock	13	175	35,645
TOTAL	50	624	119,583

3.1.1 Limitations of the Corpus

The current corpus includes both American and non-American English (i.e. British, Canadian) speakers. The possibility of limiting the lyrics to include only native American English speakers was considered but not implemented for two reasons. First, the artist associated with a particular song is not always the author of the song lyrics, and information on the real author is not always readily available. Hence, it is very difficult to determine with certainty whether the lyrics are of American or non-American origin. Second, since American music styles have been extremely influential on the music industry as a whole, it seemed reasonable to assume that differences in metaphor usage are relatively small.[8]

The genre classification should be taken as just a guideline, and a subjective one at that. There are no clearly defined characteristics and qualities which will unambiguously identify a song as belonging to one genre or another. Thus, although each song in the corpus was assigned to a single category, many would be better characterized as a combination of two or more categories.

No attempt was made to verify the accuracy of the lyrics; it is probable that some sources contained transcription errors. Minimal effort has been made to correct typographic errors in the corpus. Likewise, all punctuation, slang words, contractions, and elisions have been left intact.

3.2 Hand-Sampling

The hand-sampling task consisted of manually identifying all metaphor instances in a subset of the corpus, and tagging them. Once all instances were identified and tagged, various frequency statistics were computed to answer the following four questions:

- How frequently do metaphors occur in song lyrics?
- What percentage of these metaphors are related to emotions and mental states?
- Of those related to emotions and mental states, what percentage are conceptual metaphors and what percentage are novel? (Are conceptual metaphors as prevalent as claimed?)
- Which metaphors occur most frequently? (How much coverage can be expected, and at what cost?)

The first two questions evaluate the corpus selection, namely, how good a decision it was to use song lyrics. The last two questions get at the primary objective of this study,

[8] This is just a hypothesis.

Table 3.2 Description of the corpus subset used for hand-sampling.

Genre	Artists	Songs	Initial Word Count	Final Word Count
Blues	8	10	1392	1072
Country	9	25	4898	3784
Soft Rock	13	35	7096	5542
Alternative	10	25	5547	4548
TOTAL	40	95	18,933	14,946

which was to establish the feasibility of the knowledge-based approach for emotion metaphors.

The primary consideration in choosing a subset was selecting a representative sample from the corpus. To achieve this, songs were selected at random from each of 40 artists. All total, the subset contained 95 songs and 18,933 words (approximately 16% of the total words in the corpus).[9] Prior to analyzing the lyrics, all songs were edited to eliminate duplicate lines or refrains, avoiding overestimates of metaphors occurring in these lines. Overall this resulted in a 21% reduction in sample size to a final count of 14, 946 words. A breakdown by music genre is provided in Table 3.2.

Because hand-sampling is very labor-intensive, high accuracy (using a large sample-size) was not an achievable goal for this study. Moreover, it was not considered to be a necessary goal, as we only needed to compute rough estimates of metaphor frequencies. By extrapolating from previous empirical results, it was estimated that the subset would yield approximately 600 metaphor instances, more than sufficient for the current objectives.[10]

3.2.1 Methodology

The first step in the tagging process was to read all lyrics and identify all non-literal phrases, including idioms. A preliminary metaphor name was assigned to each instance, using metaphor names from the Berkeley Metaphor List [Lakoff et al. 91] when appropriate, and making up descriptive metaphor names for novel metaphors and instances which could not be readily classified using the Berkeley metaphors. Metaphors that combined two or more metaphors were assigned multiple names. Examples of preliminary classifications include:

We have reached a full stop.	PROGRESS-IS-FORWARD-MOTION; RELATIONSHIP-AS-JOURNEY
Keep this in mind.	MIND-AS-CONTAINER; IN-MIND-IS-AWARE-OF
My feelings swell and stretch.	FEELINGS-AS-SUBSTANCE

[9] Only 40 out of 50 artists were included because the corpus was not quite complete at the time of sampling. Later additions were made to the blues and country artists.

[10] Previous studies have estimated overall metaphor frequency to be approximately 4-5 occurrences per 100 words [Pollio et al. 90]. Additionally, Metabank results for the WSJ news corpus found that the number of conceptual metaphors leveled out at about 43 clusters after 400 metaphor instances [Martin 94]. Assuming that the behavior for the lyrics corpus is similar, then a sample of 15,000 words should yield approximately 600 metaphor instances, well into the range at which an upper bound should be reached.

(1) Check the syntactic form of the phrase
Idioms sometimes use non-standard syntax:
"by and large" and *"tripped the light fantastic"*

(2) Vary the syntax
Metaphors are frequently syntactically well-behaved, while idioms are not:
"Sally broke my heart." vs. *"My heart was broken by Sally."* (metaphor)
"Paul kicked the bucket." vs. *"The bucket was kicked by Paul."* (idiom)
"lip service" vs. *"service for lips"* (idiom)

(3) Generate extensions of the phrase
Metaphors are frequently productive:
"I gave you all my love." → *"You took all my love."* (metaphor)
"He opened up a can of worms." → *"The worms escaped from the can."* (idiom)

(4) Substitute synonyms for the source word or phrase
Synonyms or near synonyms can frequently be substituted in metaphors without destroying their meaning.
"I've walked this path before." vs. *"I've traveled this street before."* (metaphor)
"She left me in a pickle." vs. *"She left me in a cucumber."* (idiom)

Figure 3.2 Heuristics used to distinguish between metaphor and idioms (adapted from [Chin 92]). In the examples provided, * denotes a semantically anomalous phrase or sentence.

Once the preliminary tagging was complete, the set of heuristics shown in Figure 3.2 (adapted from [Chin 92]) were used to eliminate obvious idioms from the tagged text. Although closely related to metaphor, idioms frequently exhibit different structural characteristics (e.g. they often lack a systematic mapping and employ relatively fixed phrases), which would have complicated the subsequent analysis if not removed. Note that these heuristics are not always successful in distinguishing between the two. However, instances that are not distinguishable will also not have much impact on the results.

After removing idioms, the tag names were refined to eliminate redundant labels. For example, labels like LOVE-IS-A-JOURNEY and RELATIONSHIP-IS-A-JOURNEY were combined together as RELATIONSHIP/LOVE-AS-JOURNEY. Then for each of these metaphors, a unique 2 to 4-letter abbreviation was generated to tag this metaphor in the corpus (e.g. RELATIONSHIP/LOVE-AS-JOURNEY is abbreviated as RAJ). A full listing of all metaphors and their abbreviations is provided in Appendix B.

A tagged version of the corpus subset was generated using the abbreviations and SGML-style notation. For each instance, the approximate start and metaphor type were marked with a "<m=*abbrev*>" tag, followed by a corresponding "</m>" tag denoting the end of the metaphor. Metaphor combinations were tagged with multiple abbreviations separated by semi-colons. An example of tagged text is shown in Figure

```
I din't know nothin' 'bout tomorrow
<m=TAP;LAJ>I've been lost in yesterday</m>
<m=LIC>I've spent all my life</m> <m=MHP>just dying for</m>
<m=LAP>A love that passed away</m>
```

Figure 3.3 Excerpt from the final tagged subset of the lyrics corpus.
(TAP=TIME-AS-PLACE; LAJ = LIFE-AS-JOURNEY; LIC = LIFE-IS-RESOURCE;
MHP = EMOTIONAL-DISTRESS-IS-PHYSICAL-PAIN; LAP = LOVE-AS-PERSON)

3.3.
The number of instances was totaled for each metaphor and used to calculate the individual metaphor frequencies. Additionally, because many of the metaphors were derived from a common source domain (e.g. LIFE-AS-JOURNEY and RELATIONSHIP-AS-JOURNEY), frequencies for clusters of related metaphors were calculated as well. Ultimately, this proved to be the more useful statistic, and is the focus of the results presented in the next section.

3.2.2 Results

A total of 638 distinct metaphor instances were found in the hand-sampled subset, for an average of 4.3 metaphors per 100 words. Collectively, these represented approximately 191 different metaphors, 116 of which described emotions or mental states directly, 38 which were related metaphors frequently used in descriptions of emotions or mental processes, and 37 classified as not-related to either emotions or mental states (representing 430, 137, and 71 instances respectively). Of those describing emotions and mental processes, approximately 93% were common conceptual metaphors and the remaining 7% were novel uses. A listing of all 191 metaphors and their classification into emotion/non-emotion categories is provided in Appendix B.

Distribution by Target Domain

To estimate the range of emotions and mental processes these metaphors represented, the 191 metaphors were roughly grouped into different target concepts, and the frequencies for each were computed (Table 3.3). Note that these numbers are only a rough approximation since they are based on the metaphor label counts rather than each of the 430 individual instances. In particular, some labels were relatively general (e.g. EMOTION-AS-PERSON, STATE-AS-OBJECT) and could not be assigned to a specific emotion or mental state category; others represented more than one target (e.g. HAPPY/HOPE -IS-LIGHT) and were consequently counted in both. However, it is still informative to consider their relative ordering and percentages.

As Table 3.3 shows, emotion metaphors were more prevalent than descriptions of mental states (72% vs. 28% of all instances). Within the emotion category, approximately one third of the metaphors possessed labels which didn't tie them to a specific emotion. Another third were related to descriptions of love, and the remaining most prevalent emotion types consisted of happiness, sadness, "bad feeling" (a category which includes negative perceptions such as feeling "emotionally captive"), emotional stability, and fear. Of those metaphors describing mental states, almost half of them were classified under the general mental state category. Amongst those receiving more specific classifications, understanding, thought, and memory were the most common target concepts.

Table 3.3 Metaphor distribution by target domain.
Represents 430 instances, 50 of which were assigned to two groups.

Target Concept	% of All Emotion & Mental-State Instances
EMOTION	**72.3%**
general-emotion	23.1%
love	22.7%
happiness	4.6%
sadness	4.6%
bad feeling	3.5%
stability	3.1%
fear	2.9%
attraction	1.7%
freedom	1.7%
hope	1.7%
confusion	1.5%
blame	0.8%
anger	0.4%
MENTAL STATES	**27.7%**
general-mind	12.1%
understanding	5.4%
thought	2.1%
memory	1.9%
answer	1.0%
dream	1.0%
idea	1.0%
opportunity	0.8%
belief	0.6%
goal	0.6%
chance	0.2%
promise	0.2%
responsibility	0.2%
secret	0.2%
truth	0.2%

While again it should be emphasized that these numbers are estimates, they do highlight a few interesting characteristics of the song lyrics corpus. First, there is a definite bias towards expressions of love, almost certainly a consequence of the popularity of love as a theme for many songs. Second, although a variety of different emotions and mental processes were found, only a few occurred with any significant frequency. Consequently, although the corpus was definitely a good source of metaphors describing emotions and mental states in general, it does not offer very broad coverage of the range of possible emotions. Additionally, the strong bias towards love in this particular corpus suggests that corpora derived from other sources (i.e. political speeches) may have equally strong but different biases which will have to be accounted for if one wishes to model its common metaphors appropriately.

However, before one completely discounts the generality of the individual metaphor frequencies, note that it is possible this distribution *will* hold across a variety of domains if these frequencies are a reflection of a more general tendency to use metaphors for some emotions more than others. In fact, [Ortony & Fainsilber 87] found some correlation between strong positive emotions and increased metaphor usage. Certainly more research in this area is needed before any strong conclusions can be made.

Distribution by Source Domain

The 191 unique metaphors were clustered by source domain into 45 groups of related metaphors plus a miscellaneous category. The top 25 of these groups are listed in Table 3.4. As highlighted by the shading in the table, the top five metaphor groups account for a total of 50% of all the instances, and the top ten groups account for 69%. Examples and descriptions of the types of metaphors contained in each of the top five groups are provided in Figures 3.4 & 3.5.

Table 3.4 Top 25 metaphor groups by source domain.
Represents 656 in all (638 instances, 18 of which belong to two groups)

METAPHOR GROUP (by source concept)	INSTANCES	PERCENT OF TOTAL	CUMULATIVE COVERAGE
object/possession	129	20%	20%
journey	70	11%	30%
container	53	8%	38%
proximity	44	7%	45%
vision	31	5%	50%
non-person as person	29	4%	54%
health	28	4%	59%
orientation	28	4%	63%
light	24	4%	66%
stability	17	3%	69%
structure	15	2%	71%
captor	12	2%	75%
war	12	2%	77%
gambling/games	10	2%	79%
place	10	2%	80%
fire	10	2%	82%
forces	9	1%	83%
weapon	9	1%	84%
commodity	7	1%	84%
color	7	1%	85%
music	7	1%	86%
person as inanimate	7	1%	87%
cost	7	1%	88%
person as animal	6	1%	89%
water	6	1%	90%

Object, Possession, Substance, Moving Object - 129 instances (20%)
Metaphors in this group view emotions, thoughts, and people as objects or substances. Aspects of the source domain which are frequently salient: physical characteristics (e.g. structural strength), possession/ownership, movement.

Examples:

You said when you lost her you lost everything
I had nothing but the blues
Those feelings came back again
Her good bye hit me in the heart
you stole my idea
promises get broken

Journey (Life, Love, Thought) - 70 instances (11%)
Journey metaphors for life, love and thought rely upon several characteristics of a journey: a start and destination (desired state), possibly obstacles in the path, and progress is measured by movement towards the destination.

Examples:

Need to keep one step ahead of every chance
You don't care what might lie ahead
I've had my share of wrong directions
Maybe we've only just begun
I've reached a natural conclusion
We've been running around in circles

Container (Person, Heart, Mind, Eyes, State) - 53 instances (8%)
Container metaphors draw upon the physical characteristics of containers: they have insides and outsides, protect/hide, and sometimes confine/constrain their contents. Container metaphors frequently occur with the DEPTH = CENTRALITY metaphor, and object/substance metaphors for the contained entity (esp. emotions).

Examples:

I noticed you goin' out of your mind
I gave my best smile but I was dying inside
Why are my eyes always full of this vision of you
I was afraid to let you in here
when we're open to each other
I was the one, caught in the moment
their hearts were filled with memories, their bodies filled with hurt

Figure 3.4 Examples of OBJECT/POSSESSION, JOURNEY, and CONTAINER metaphors found during hand-sampling.

Physical Proximity is Strength of Effect - 44 instances (7%)
Proximity metaphors equate physical proximity with the strength or health of a relationship, emotional or mental influence/support/agreement.

Examples:

But no one new can reach her
You'd better keep your distance, don't let her reel you in
it's really gettin' to you
Why did I ever let the distance grow
I see us inside of each other
I'm here but I'm really gone

Seeing is Understanding - 31 instances (5%)
Most vision metaphors map directly between "see" and "understand". Other aspects of vision which are sometimes used: color, shadow, sight quality.

Examples:

we could never see eye to eye
one of us just must be blind
See what we want to see
I was blinded by the love in my eyes
as the scenery grows, I see in different lights

Figure 3.5 Examples of PROXIMITY and VISION metaphors found during hand-sampling.

These results are encouraging, because they support the hypothesis that the majority of metaphors can be accounted for by just a few common conceptual metaphors. Additionally, most of the metaphors draw upon a few source domains, particularly physical objects, the human body, and spatial relationships. This is important because it indicates the number of source domains of which the system needs knowledge is relatively limited.

In the current work, the top five of these metaphor groups were selected for implementation. The remainder of this thesis focuses specifically on these five metaphor groups, and the steps involved in incorporating them into PoEM.

3.3 Directed Search

Subsequent to hand-sampling, a directed search was performed for the top five metaphor groups to identify additional instances of each metaphor. The goal of this study was to get a better understanding of the types of cross-domain mappings used by these metaphors and the common syntactic and lexical forms they assumed. Specifically, the instances found by the search were analyzed with the following questions in mind:

- How "frozen" is the metaphor group? Are there specific words which serve as good predictors for the metaphor(s)?
- What syntactic forms do the metaphors assume? Are there

recognizable syntactic patterns such as "*<noun x> is <noun y>*" or "*<noun x> <verb y> <object>*"?
- Is the target concept explicitly mentioned or implied?
- What types of mapping occur (i.e. physical attribute, behavior, etc...)?

The subset of the corpus used for the task consisted of everything not used in the previous hand-sampling task, excluding data reserved for subsequent testing of the implemented system. In all, it contained 397 songs (75,687 words) representing all 50 artists. Unlike the hand-sampling task, repeated lines and refrains were left intact, since it was not important to the current study (no frequency estimates were being generated from the results). Table 3.5 lists the breakdown of the searched subset by genre.

Table 3.5 Description of the corpus subset used for directed-search.

Genre	Artists	Songs	Words
Blues	15	89	15,138
Country	12	115	23,114
Alternative	10	80	15,023
Soft Rock	13	113	22,412
TOTAL	50	397	75,687

3.3.1 Methodology

The directed search is based on the observation that because metaphors describe their targets in terms of their source concepts, they usually include explicit references to the source. By searching for words related to the source domain, one should be able to identify a large percentage of all metaphor occurrences. The key is to limit the number of false matches by avoiding common words.

A list of search terms was generated for each metaphor group using word frequency counts of the metaphor instances identified during hand-sampling. Any words clearly related to the source domain were added to the list. For example, JOURNEY metaphors included 19 occurrences of "*way*", 17 occurrences of "*to*", and 12 occurrences of "*you*". The word "*way*" is commonly used to describe various aspects of journeys (as in "*the way*" or "*a way*"), so it was included in the list. However, "*you*" was not considered to be part of the source domain of journeys, and "*to*" was considered to be too common to be useful, so they were omitted.[11]

The lists also included different inflected forms of the words, (e.g. "*go*", "*going*", "*gone*", "*goes*", and "*went*") and words related by synonymy and antonymy (e.g. "*behind*" & "*ahead*"). An example of a completed search list for the CONTAINER metaphor group is shown in Figure 3.6.

Originally, the goal was to generate search lists providing 100% search recall of the metaphor instances from the sampling task. However, this goal was quickly abandoned upon realizing that it was achievable only if very long word lists were employed, at the expense of discriminatory ability (particularly true for the OBJECT/POSSESSION instances). The number of terms in the final lists and upper bound estimates of their coverage (using recall on the sampling results) are summarized

[11] Many of the high frequency terms omitted from the lists (esp. pronouns) are somewhat indicative of the presence of a metaphor, but because they are so common, these terms were considered to have too little discriminatory capability to be included.

```
in, inside, into
out, outside
deep, deeper, deepest
fill, filled, filling, fills
hollow, shell
empty, full
open, opened, opening, opens
close, closed, closing, closes
nothing, all
```

Figure 3.6 Search word list used for the CONTAINER metaphor group.

Table 3.6 Summary of the number of search terms used for each metaphor group. The first number in the second column indicates the number of unique base forms of words, the second number includes inflections in the count.

Metaphor Group	Search Terms	Maximum Estimated Coverage
Object/possession	26/88	74%
Journey	33/100	87%
Container	15/26	92%
Proximity	21/52	86%
Vision	11/33	100%

```
 I find? Maybe I'd rather just walk around blind I know baby loves me,
      mine I drove her out, I must've been blind That's the thoughts of a
    mind sometimes I think I must be going blind I've seen a world baby
       come a day when those that you keep blind will suddenly realize maybe
    left to take the lead I've been loving blind Loving every heart I could
  heart I could call mine I've been loving blind So sure there was something
      ever believed That love had to be so blind When freedom was waiting, down
      so sincere, how could our love be so blind We sailed on together, we
              woman I love But I can be so blind, the good times I sometimes
     true love With another Why were we so blind It was right here All
start to lovin', she bring eyesight to the blind Her daddy must have been
        Possibly be you? I was lost, I was blind Till I loved you Wouldn't
      just took some time to realize I was blind I couldn't tell Put too
       stare the sun down until my eyes go blind Hey, I won't change direction,
poured my heart out It evaporated ... see? Blind man at a canyon's edge
```

Figure 3.7 Sample output from a directed search for VISION metaphors using the term *"blind"*.

in Table 3.6.

All occurrences of each search term found in the corpus subset were stored along with the surrounding context (8 words to either side of the search term). An example of the contexts found for occurrences of the word *"blind"* is shown in Figure 3.7 (with the right context truncated due to space constraints). The results were sorted using words preceding or following the search term to aid identification of syntactic patterns and word co-occurrences.

After collecting all occurrences, each list was scanned to determine whether or not it was worth including in the final analysis. Lists with only a few examples, or which contained relatively few metaphors in comparison to non-metaphoric uses were discarded.

3.3.2 Results

Of the 299 initial search terms, only 45 were found with sufficient frequency in metaphoric contexts to merit further analysis. These terms and examples of their metaphoric usage are summarized in Table 3.7. Each table entry is a psuedo-syntactic pattern generalized from multiple metaphor instances. Italicized entries in the table represent general concept classes, which include both individual words and phrases. For example, the word *"happiness"* and the phrase *"the overwhelming sorrow"* are both considered to be valid members of the *emotion* class. Angle brackets and parentheses denote word sets and optional items respectively.

Lexical and Syntactic Regularities

As expected, the five metaphor groups varied considerably in how fixed their lexical and syntactic forms are. By far the most static are VISION metaphors, which generally include either the word *"see"* or *"blind"*. In contrast, search terms used for JOURNEY metaphors exhibited the greatest lexical and syntactic variation, and often more than a 17-word context was required to determine whether or not the usage was an example of a JOURNEY metaphor. Additionally, some JOURNEY metaphor instances do not make explicit reference to the target concept at all; the metaphoric usage had to be inferred from the general topic of the lyrics.

Not all inflected forms were useful, suggesting that some metaphors may be correlated with a particular voice (most often 1st person), part of speech, or tense that reflects their typical usage. For example, *"end"*, *"ends"*, *"ended"*, and *"ending"* were all search terms for JOURNEY metaphors, but only *"end"* was used with relatively high frequency, suggesting that *"end"* may be more common as a noun than as a verb. Another example is the word *"take"*, which occurred much more often (165 times) than either *"taken"* (9 times), *"taking"* (2 times) or *"took"* (46 times). Thus, metaphors using this verb describe present or future events more often than the past.

Generally, the predictive value of each search term depends greatly on how common their relative metaphoric and literal uses are in the genre of song lyrics. For example, "blind" was found to be a useful indicator of VISION metaphors, because few song lyrics contain references to literal blindness, but often describe misunderstanding or confusion.

Co-occurring Metaphors

Some metaphors tend to co-occur regularly with others. It is common to find JOURNEY metaphors with STATE/EMOTION-AS-LOCATION metaphors where physical locations frequently represent mental states, emotions, and other abstract events occurring during the course of the relationship or life. For analogous reasons, both PROXIMITY and CONTAINER metaphors often co-occur with OBJECT/POSSESSION metaphors because PROXIMITY metaphors are often used to describe degrees of possession, and CONTAINER metaphors are used to *"contain"* emotion or mental state objects.

Table 3.7 Common lexical and syntactic forms of the five metaphor groups.
Typeface conventions: individual word, **search term**, *word class*, <set of words>, (optional item).

Metaphor Group	Search Term	Common Usage in Metaphors
Object/ Possession	found	<*person*> **found** <*emotion; person; mental state*>
		<*emotion; person*> (that) <*person*> **found**
	gave	<*emotion; thoughts*> (that) <*person*> **gave** (to) (<*person*>)
		<*person*> **gave** <*person*> <*emotion; thoughts*>
	give	(<*person*>) (<*modal*> (not)) **give** (<*person*>) <*thoughts; emotion; heart*>
	gone	<*emotion; thoughts*> <*be-verb*> **gone**
	got	<*person*> <*aux.verb*> (not) **got** <*emotion; thoughts*>
	had	<*emotion; mental state*> (that) <*person*> **<had; have>**
	have	<*person*> **<had; have>** <*emotion; mental state*>
	hold holding	<*person*> <*aux.verb*> (not) **<hold; holding>** <out; onto> <*emotion; thoughts; heart*>
	keep	<*person*> <*aux.verb; modal*> (not) **keep** <*emotion*>
		<*person*> <*aux.verb; modal*> (not) **keep** <*person*> for <*possessive*>
	lose	<*person*> <*aux.verb; modal*> (not) **lose** <*person; emotion; thought; body part*>
	mine	<*person; heart; emotion*> <*aux.verb; modal*> (not) **mine**
	take	**take** (away) <*emotion*>
	without	<*person*> <*resulting state*> **without** <*emotion; person*>
		without <*emotion; person*> <*person*> <*resulting state*>
	my, our, your	**<our; my; your>** <*emotion; thoughts; hearts*>
Journey	ahead	<*person*> <*get-verb*> **ahead** in <*life; love*>
		<*person*> <*look-verb*> **ahead** and <*see-verb*> <*emotion; mental state*>
	back	<*life; love*> <*be-verb*> **back** on track
		<*person*> <*travel verb*> **back** to <*mental state; love*>
	behind	<*emotion; mental state*> (<*be-verb*>) (<far; all>) **behind** <*person*>
	end	<*prep*> the **end** of <*possessive*> <*life; love*>
	far	<*person*> <*travel verb*> <*adj*> **far**
		how **far** <*person*> <*travel verb*>
	lost	<*person*> <*be-verb*> **lost** <until; without> <*person; love*>
	over	<*person*> get **over** <*person; love*>
		<*relationship; life*> <*be-verb*> **over**
	road	**road** to <*mental state; emotion*>
	start	<*person*> <*modal*> (not) **start** <over; again> (<in; with> <*life; love*>)
		<*person*> <*modal*> (not) make a new **start** (<in; with> <*life; love*>)
	through	<we; I> <*verb phrase*> **through** <*mental state; emotion*>
	turn	<*life; love*> <*modal*> <*take*> (wrong) **turn**
		which **way** <*modal*> <*person*> **turn**
	way	<*person*> <*aux.verb; modal*> (not) <*find; lose*> <*det*> **way** (<to; from> <*mental state; emotion*>)
		<*show-verb; give-verb*> <*person*> <*det*> **way** to <*mental state; emotion*>

Table 3.8 Common lexical and syntactic forms of the five metaphor groups (continued)

Metaphor Group	Search Term	Common Usage in Metaphors
Container	filled	<*person; body part*> <*be-verb*> **filled** with <*emotion; thoughts*>
		<*emotion; thoughts*> **filled** <*person; body part*>
	full	<*person; body part*> **full** of <*emotion; thoughts*>
	in	<*emotion*> <*person*> kept **in**
		<*emotion; thoughts*> **in** <*person; body part*>
	inside	<*emotion; thoughts*> (that <*action*>) **inside** (of) <*person; body part*>
	into	**into** <*person; body part*>
	open	**open** (up; with) <*person; body part*>
		<*person; body part*> **open** up
	out	(pour; let) <*emotion*> **out**
		(<*modal*>) (not) get <*person*> **out** of <*body part*>
Proximity	away	<*verb*> <*emotion; person*> **away** (from <*person*>)
		<*emotion; thought*> fade(s) **away**
		<*person*> <*run; walk*> **away** (from <*person; emotion*>)
	close	<*person*> <*get-verb; aux.verb*> (too; so) **close** (to <*person; heart*>)
	leave	<*person*> **leave** <*emotion*> (behind; outside)
	left	<*person*> **left** <*person*>
	near	<*person*> <*come; is*> **near** (to) <*person; heart*>
	stay	<*person*> <*aux.verb; modal*> **stay** (with <*person*>)
		<*person*> <*want-verb; need-verb; make-verb*> <*person*> to **stay**
Vision	blind	<*love*> <*aux.verb; modal*> **blind**
		<*person*> <*aux. verb; modal*> **blind** (until <*clause*>)
	blinded	<*person*> <*aux.verb; modal*> **blinded** (by <*emotion; thought*>)
	see	<*person*> <*aux. verb; modal*> (not) **see** <*emotion; idea; thought*>

Typical Interpretations

Table 3.8 summarizes some common interpretations of the metaphor groups and the source characteristics used to convey them, derived from the directed search results. These metaphors typically describe general characteristics of an emotion or mental state. They may communicate one's current state or describe a change of state to the listener, or offer a viewpoint about another person's internal state. Quite often, they are used to communicate the intensity of an emotion. They also describe causal relationships between emotions and the events or people which gave rise to them.

In almost all instances, temporal information conveyed by tense is important to the final interpretation of the metaphor. Temporal information provides clues regarding whether the current statement reflects a change of state (through reflection on past events), or an appeal to the listener for assistance (via reference to a present undesirable state).

Table 3.9 Typical interpretations and source characteristics used by the five metaphor groups.

Metaphor Group	Interpretation	Source Characteristics
Object/ Possession	Possession status (for possessor and thing possessed)	Possession/transfer verbs (e.g. *"give"*, *"have"*, *"take"*). Subject and object positions specify the possessor and item possessed
		Noun phrases modified by a possessive pronoun. Noun is the item possessed and pronoun specifies the possessor.
	<*person*> no longer possesses, and may want to recover, a person, mental state, or emotion	Use of the verb *"lose"*, in statements of the form <*person*> lose <*person; emotion; mental state*>
	Possession status & implication of possible conflict	Use of a verb such as *"take"* or *"steal"* which may indicate taker/giver were not in full cooperation with one another.
	Causal relationship between emotions, personal relations, and a person's outlook	Use of *"without"* in statements of the form <*resulting state*> without <*person; emotion*>
Journey	Measure of progress in relationship or life (comparison of past or future emotions with present state)	Relative position and distance in the journey w.r.t. locations along the route using prepositional phrases or adjectives (e.g. *"ahead"*, *"behind"*, *"back"*, *"through"*, *"far"*). The complement of the prep. phrase usually specifies the emotion/state under comparison with present emotions/states.
	Request for guidance; description of problems encountered	Route planning and path references using nouns such as *"turn"* and *"way"*. Direction modifiers of the path references provide additional information about the quality of progress (e.g. *"**wrong** turn"*)
	Communication of relationship status; request for assistance to fix problems	References to the origin and destination of the journey using *"start"* and *"end"* nouns.
	Source of guidance for <*person*> is <*person; emotion; mental thing*>	Use of *"lost"* in statements of the form <*person*> <*be-verb*> lost <without; until> <*person; emotion; mental thing*>

Table 3.10 Typical interpretations and source characteristics used by the five metaphor groups (continued)

Metaphor Group	Interpretation	Source Characteristics
Container	Quantification of emotion; also expression of need when desired emotion is lacking	Adjectives quantifying amount of substance in a container (e.g. *"full"*, *"empty"*)
	Request for access to another person's emotions	Container access verbs such as *"open"*
	Description of current, past, or future mental or emotional state.	Containment prepositions such as *"in"*, *"inside"*, *"into"*, *"out"*
Proximity	Quantification of emotion intensity and influence over person	Expressions of relative distance using prepositional phrases containing *"near"*, *"close"*, *"away"*
	Expression of desire or lack of desire for particular emotional state or relationship with a person	Co-location or separation actions using verbs such as *"stay"* or *"leave"*, where the verb complement is usually the emotion or person which is desired or not wanted.
Vision	Self reflection; communication of a change of state (usually from not understanding to understanding)	First-person statements (often past tense) about sight or lack of sight. Sometimes includes causal information about what prevented or enabled sight using a prepositional phrase of the form <*by; until; with*> X
	Expression of confusion; request for clarification	Present tense statements about lack of sight
	Expression of personal views about what listener will understand or recognize in the future	Second person statements of the form <*person*> will see X
	Degree of understanding	Reference to the quality of vision using focus and light

3.4 Summary

In this chapter, two empirical studies have been described: a hand sampling and a directed search in a corpus of song lyrics. The hand sampling task determined the overall metaphor frequency and the distribution of individual metaphors in the lyrics corpus. The directed search was used to study the five most common metaphor groups of the corpus in greater detail, identifying specific syntactic and lexical patterns assumed by the metaphors along with their interpretations.

The results of the random sampling were remarkably consistent with those of previous studies. The overall frequency rate of 4.3 metaphors per 100 words is just slightly lower than the 5 metaphors per 100 words reported previously [Pollio et al. 90]. As found in the Metabank study [Martin 94], most metaphor instances in the lyrics corpus are conceptual metaphors rather than novel uses (93% vs. 7%), and most instances are distributed amongst relatively few metaphors, with the top five metaphor groups accounting for about half of all occurrences. The primary difference between the current and previous studies is in which metaphors were found most often. As expected, the individual metaphor frequencies reflect the topics of the corpus. In song lyrics, approximately 67% of all metaphors were either emotion or mental state metaphors, with a preponderance of metaphors for love.

The directed search study of the OBJECT/POSSESSION, JOURNEY, CONTAINER, PROXIMITY, and VISION metaphor groups showed that these metaphors vary considerably in lexical and syntactic predictability, but have a relatively small number of interpretations. VISION metaphors used the smallest number of syntactic patterns, while JOURNEY and PROXIMITY metaphors were the most difficult to provide generalizations for. Common interpretations for the metaphors are communication of a current state, often in contrast to some earlier state, description of emotional intensity, and solicitation (offers) of assistance from (to) another person.

Collectively, the results of these two studies estimate how viable it is to construct a system by explicitly modeling the structure of common metaphors. While the random sampling results are quite encouraging, the directed search results suggest that it may be difficult to provide a model covering all possible syntactic and lexical variations. Consequently, we expect that performance for a system built using this approach will be poorest for metaphors like the JOURNEY or PROXIMITY groups. These results also suggest that while metaphor identification may be difficult for some metaphors, interpretation should be easier once they have been identified. Note however, that capturing subtleties of individual metaphors presented by modifiers may still be quite challenging.

Several interesting issues arose during the course of completing these two studies. First is the issue of metaphor combinations or blends. In the current study, each metaphor was considered independently of any other; better characterization of how these combinations work together to construct meaning is still needed. The second issue was identifying the boundaries of a metaphor, or the appropriate "meaning unit" to use. This issue is particularly important if one wishes to tag the original text rather than produce a semantic interpretation of the input. Setting metaphor boundaries to coincide with phrase boundaries may be sufficient for most instances, but some metaphors rely on implicit reference or make use of larger contexts to identify their target concepts. The third and final issue was that of identifying the appropriate level of detail and output format for the interpretations. In other words, how can we be sure the output representation produced captures all the essential details of the metaphor? In the directed search, interpretations were made at a very high level; however, in actual applications, additional information may be necessary.

4 The PoEM System

PoEM is a prototype system based on the empirical results presented in the previous chapter. It recognizes and interprets a limited set of metaphors describing emotions and mental states, namely metaphors of the top five metaphor groups of the study: OBJECT/POSSESSION, JOURNEY, CONTAINER, PROXIMITY, and VISION metaphors. The syntactic and lexical patterns identified in the study have been translated into a set of metaphor templates used to identify possible metaphors. Their corresponding interpretations are the basis for the interpretation rules applied once a metaphor is identified.

This chapter details the design and implementation of PoEM. Section 4.1 presents an illustration of the system in operation. Section 4.2 briefly discusses the design criteria and methodology that guided development. Section 4.3 explains the pre-processing routines used by the system. Sections 4.4 and 4.5 describe the implementation and use of metaphor templates and interpretation rules respectively. Section 4.6 describes the use of WordNet in the knowledge base supporting the recognition and interpretation processes. Finally, a brief summary and discussion of the advantages and shortcomings of the current implementation are presented in Section 4.7.

4.1 An Illustration

Before describing the details of PoEM, let us illustrate how the system works with a simple example. Figure 4.1 contains a trace of PoEM's processing and final output for *"Love blinded me."* The sentence is first preprocessed by a part-of-speech tagger and simple phrasing routine. It is then compared against all metaphor templates to identify possible matches. In the current example, only one match was found (SEEING-IS-UNDERSTANDING), but generally, a single sentence may match multiple templates. Each successful match results in a set of role bindings such as those shown in lines 5-7 of the execution trace. The final output is then constructed by translating each set of role

```
USER(12): (interpret "Love blinded me.")
;; PHRASING: "Love blinded me."
;; TESTING: "Love blinded me."
;;; got one
((?PRES C) (?AGENT NP (NNP "Love" ROOT "love")) (?PREV)
 (?ACTION VB (VBN "blinded" ROOT "blind")) (?POSTV)
 (?OBJECT NP (PRP "me" ROOT "I")) (?POSTO))
Metaphor: SEEING-IS-UNDERSTANDING Index: 1
;; INTERPRETING ...
I did not understand <something> because of Love
```

Figure 4.1 Trace of PoEM processing for *"Love blinded me."* (edited for clarity).

bindings according to the interpretation rule of the matching template. Here, the rule for the matched SEEING-IS-UNDERSTANDING template gives rise to the interpretation *"I did not understand <something> because of Love"*. The marker *"<something>"* indicates information that could not be determined from the input.

These processing stages are schematically illustrated in Figure 4.2. The main interface, recognition, and interpretation routines are all implemented in Common Lisp. Pre-processing is handled externally via a set of Perl scripts called by the Lisp programs. At each stage, the WordNet lexical database [Miller et al. 97] provides additional semantic information to PoEM.

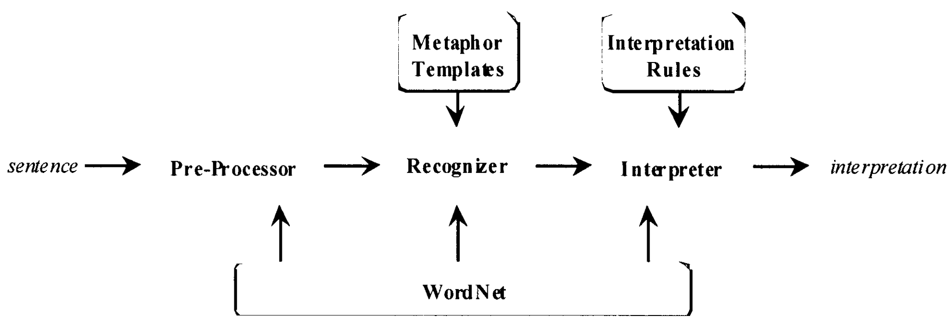

Figure 4.2 Major processing stages of PoEM

4.2 Design Approach

PoEM was implemented to provide a base system for future work in metaphor comprehension. The emphasis here is not on cognitive theory, but on developing a practical approach (analogous to recent tagger and parser development) which can be used in general natural language systems. To achieve this, four design guidelines were followed:

- **Modularity** - Parsing, recognition, interpretation, and knowledge representation should be fairly modular in order to simplify upgrades of any of the subsystems as improved techniques and resources are developed.
- **Extensibility** – Ideally, the system should be able to be expanded or customized for a different metaphor domain with minimal effort.
- **Knowledge reuse** - Existing sources should be utilized when possible to provide a supplemental knowledge base.
- **Metaphor coverage** - To ensure maximum coverage with minimal effort, empirical data should be used to support metaphor selection.

4.2.1 Coverage

The five most common metaphor groups identified by the empirical study presented in Chapter 3 were selected as the focus for PoEM. Currently, PoEM includes enough knowledge to process single sentences containing the following metaphors:

EMOTIONS-AND-THOUGHTS-ARE-PHYSICAL-OBJECTS/SUBSTANCES
A-LOVED-ONE-IS-A-POSSESSION
LIFE/LOVE/THOUGHT-IS-A-JOURNEY

PEOPLE-ARE-CONTAINERS (for thoughts and emotions)
PHYSICAL-PROXIMITY-IS-STRENGTH-OF-EFFECT
SEEING-IS-UNDERSTANDING

4.2.2 Assumptions

PoEM approaches metaphor comprehension from the perspective that metaphor is a particularly succinct and apt way of expressing a speaker's communicative goal. Consequently, the overall objective of the system is to produce an interpretation of the metaphor which makes this communicative goal explicit.

In addition to assuming that every metaphor is used with a particular communicative goal in mind, PoEM makes three simplifying assumptions about the information structure of the input.

Assumption #1: *The theme or topic of each sentence is the material preceding the verb, and will always be related to the target domain.*

Since the goal of a metaphoric utterance is to describe a target concept, one expects references to the target to serve as the theme (topic) of the sentence. In English, the theme typically corresponds to the subject material (preceding the verb). Thus, for the target domain of emotions and mental states, the subject material should contain a reference to a mental state, an emotion, or the agent experiencing the emotion or mental state. This assumption is applied even in the passive case, for although the subject may not correspond to the agent role of the sentence, it is still where the focus of the sentence is being placed.

Examples:

My feelings swell and stretch.	(EMOTION-AS-OBJECT)
This **relationship** is going nowhere.	(LOVE-IS-A-JOURNEY)
Love blinded me.	(SEEING-IS-UNDERSTANDING; emphasis on the cause)
I was blinded by love.	(SEEING-IS-UNDERSTANDING; emphasis on the person)

Note that this assumption is not always true, particularly for more complicated syntax. Additionally, if the topic is a person (i.e. *"I"*), we often need additional references to the target domain in order to determine whether or not the sentence is metaphoric. For instance, it is not clear whether *"**I**'ve had my share of wrong directions"* is metaphoric, unlike *"**I**'ve had my share of wrong directions in **life**"*.

Note also that by restricting consideration to those metaphors containing explicit references to the target concept, it is possible to analyze individual sentences without maintaining an input history or context model, thus simplifying the design requirements.

Assumption #2: *Verb and post-verb material constitute the new information about the topic, and will contain at least some material from the source domain.*

Since metaphor defines the target in terms of the source, we expect metaphor will always include some explicit reference to the source domain. As shown in the previous chapter, verbs and prepositions used in a metaphoric statement often come from the source domain. Somewhat less-common forms used by metaphors include the stative case referring to the source domain in the verb complement, and the related case in which the source domain material is used as a modifier.

Examples:

My feelings **swell** and **stretch**.
This relationship is **going nowhere**.
I was **blinded** by love.
I am feeling **empty**.

Assumption #3: *Each "idea unit" in the input is a possible source of new information and should be analyzed.*
To ensure maximum identification of metaphoric usage, including the occurrence of multiple metaphors in a single sentence, the input must be analyzed at the level of the smallest meaningful "idea unit". Currently, PoEM uses the three "idea units" listed in Table 4.1, which essentially correspond to predicate-argument representations for verbs, prepositions, and modifiers.

Note this assumption implies a metaphor can be analyzed piecemeal. In other words, the meaning of a metaphor is equivalent to the sum of its component metaphors. This assumption is also a simplification, based on the observation of the previous chapter that when metaphors co-occur, they frequently address different and complementary aspects of a concept.

4.3 Pre-processing

The individual routines comprising the pre-processing stage are shown in Figure 4.3.

Table 4.1 "Idea units" used by PoEM to analyze information. Arguments marked with an asterisk * are optional.

Idea unit	Information content	Examples
verb(subject, object*)	Describes an action, the agent performing the action, and the direct/indirect object of the act.	swell(*"feelings"*) go(*"relationship", "nowhere"*) blind(*"love", "me"*)
prep(complement, subject*)	Provides additional information about location, manner, cause, or instrument.	inside(*"me", "love"*) without(*"your love"*)
modifier(head word)	Specifies an attribute for the head word.	empty(*"I"*) broken(*"heart"*)

These include tokenization, part-of-speech tagging, morphological analysis, phrasing, and text formatting. Most of the routines are implemented in Perl, which is also used to provide the client/server interface to the Brill tagger and to access morphological information in WordNet. The phrasing routines also use the CELEX Lexical Database of English [Baayen et al. 95].

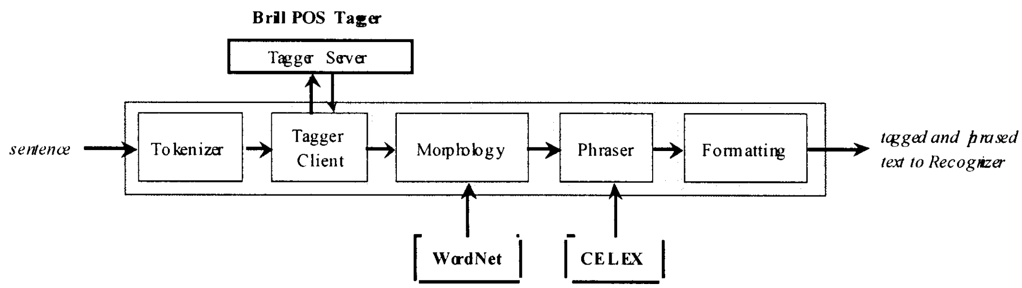

Figure 4.3 PoEM pre-processing modules. Client/server scripts provide an interface to the Brill tagger and manage the rest of the text pre-processing tasks.

4.3.1 Tokenization and Tagging

Input is tokenized in accordance with the Penn Treebank tokenization rules [Santorini 90]. Spaces are inserted to isolate individual tokens including contractions, punctuation, and symbols. All quotes are replaced with matching sets of double quotes "". Slang terms (e.g. *"gonna"*, *"wanna"*) are also replaced to avoid problems these terms may cause at later stages in the processing.

The tokenized input is then passed to the Brill Rule-Based Part-of-Speech Tagger [Brill 94]. The tagger uses rules and a lexicon derived from the Wall Street Journal and Brown corpora, and produces tagged output using the Penn Treebank tag set [Santorini 90; Marcus et al. 93].

4.3.2 Morphological Analysis

A simple morphology program supplied with the WordNet 1.6 distribution [Miller et al. 97] is used to determine the root forms of nouns, verbs, and adjectives. The morphology routine uses exception lists in combination with a set of standard transformation rules to create candidate base forms, which are then checked against the WordNet database. If the base form is found in WordNet then it is accepted.

Since WordNet does not cover pronouns, a separate lookup table is used to convert each pronoun to its nominative form.

4.3.3 Partial Phrasing

After tagging, the input is partially phrased using a simple grammar. Noun phrases, verb material, and prepositional phrases are identified and labeled. Punctuation and conjunctions are used to identify probable clause boundaries. Conjunctions, adverbs, and any other remaining items are left alone. To help distinguish between particles and prepositions (e.g. *"blew out the candles"* vs. *"flew out the window"*), the phrasing routine uses particle information of the CELEX Lexical Database of English (Release 2.5) [Baayen et al. 95].

Currently, these grammar rules are very primitive. They do not determine prepositional phrase attachment or handle movement phenomena, and any mistakes made during tagging will be perpetuated and sometimes made worse during the phrasing.

4.3.4 Text Formatting

The final step in the pre-processing converts the tagged and phrased input into a format suitable for Lisp. An example of this format is presented in Figure 4.4.

```
((C (NP (PRP "I" ROOT "I"))
  (VB (VBD "was" ROOT "be") (VBN "blinded" ROOT "blind"))
  (PP (IN "by" ROOT "by")
   (NP (DT "the" ROOT "the") (NN "love" ROOT "love")))
  (PP (IN "in" ROOT "in")
   (NP (PRP$ "my" ROOT "I") (NNS "eyes" ROOT "eye"))))
 (PUNC "."))
```

Figure 4.4 Pre-processed form of the sentence *"I was blinded by the love in my eyes."*

4.4 Metaphor Identification

Metaphor identification encompasses both recognizing an instance of a metaphor, and mapping sentence constituents to corresponding components of the identified metaphor. To achieve this, PoEM uses metaphor templates in combination with pattern matching techniques.

4.4.1 Metaphor Templates

Specific knowledge about the semantic role restrictions and syntactic structure of individual metaphors is stored in the form of *metaphor templates.* Each template is organized around one of the three basic "idea unit" representations described in Section 4.2, where both predicate and arguments are variables subject to semantic constraints.

One example is shown in Figure 4.5 for the metaphor PEOPLE-ARE- CONTAINERS. The template is organized around a verb predicate, stipulating that instances of this metaphor include a verb which is a member of the **container-action** semantic category, an agent (syntactic subject) belonging to the **mental-thing** category, and an object which is either a **human** or a **body-part**. Sentences matching this template include *"Love filled my heart"*, *"Bad thoughts shall leave your mind"*, and *"The sorrow entered her heart."* Note that each template specifies just a subset of possible CONTAINER metaphors. PoEM currently has five CONTAINER metaphor templates in all, covering a fraction of all possible syntactic structures.

Template for PEOPLE-ARE-CONTAINERS

?action(?agent, ?object) such that:

?action $\in$ **container-action**

?agent $\in$ **mental-thing**

?object $\in$ **human** or **body-part**

Possible Instantiations

fill(*"love"*, *"my heart"*)	*"Love filled my heart."*
leave(*"bad thoughts"*, *"your mind"*)	*"Bad thoughts shall leave your mind."*
enter(*"sorrow"*, *"her heart"*)	*"The sorrow entered her heart."*

Figure 4.5 Sample metaphor template for PEOPLE-ARE-CONTAINERS. Boldface items represent semantic category restrictions for the arguments of the template, and variables are prefixed with a "?".

Each template is a generalization of the syntactic and lexical patterns identified by the empirical study of Chapter 3, where specific lexical selections have been replaced by semantic categories. These categories were determined by looking at patterns in both the directed-search and hand-sampling results, and by applying knowledge about the source and target domains to achieve maximum possible coverage.

Successful application of these templates depends critically on having well-defined semantic categories which are broad enough to be useful without being overly general. For example, the **mental-thing** category must be defined such that it includes *"sorrow"*, but not *"tears"*, in order to distinguish between the metaphoric utterance *"sorrow filled her eyes"* and the literal utterance *"tears filled her eyes."* Details regarding the implementation of these categories using the semantic relations in WordNet are presented later in this chapter.

4.4.2 Pattern Matching

Each template is implemented as a pattern like the one shown in Figure 4.6. Variables and special predicates used by the pattern matcher begin with a "?". Acceptable matches for variables are constrained by boolean functions which test category membership. For example, given the `(?is ?agent mental-thing)` pattern of Figure 4.6, the variable `?agent` is bound to an input word or phrase which is a member of the **mental-thing** category. Variables terminated with a "*" are special variables which bind to zero-or-more words of the input. These are used to increase the matching flexibility by allowing other words to occur between matched items. Constraint functions prefixed with "?ok" are used to specify the kinds of words (e.g. determiners, conjunctions, adverbs, etc.) which can be bound to these special variables.

The system will try to find as many metaphors as possible in the input. A pattern matcher [Norvig 92] compares each template pattern against the phrased input for possible matches. Each match returns a set of variable bindings like those of Figure 4.7,

```
(defpattern 'PERSON-IS-CONTAINER
       (?preS* ?ok-preS
       (?is ?agent mental-thing)
       ?preV* ?ok-preV
       (?is ?action container-action)
       ?postV* ?ok-postV
       (?or  (?is ?object body-part)
             (?is ?object human-agent))
       ?postO* ?ok-postO))
```

Figure 4.6 Implemented form of a template for PEOPLE-ARE-CONTAINERS

```
(((?PRES C) (?AGENT NP (NN "Love" ROOT "love")) (?PREV)
  (?ACTION VB (VBD "filled" ROOT "fill")) (?POSTV)
  (?OBJECT NP (PRP$ "my" ROOT "I") (NN "heart" ROOT "heart"))
  (?POSTO))
 :METAPHOR PERSON-IS-CONTAINER :INDEX 0)
```

Figure 4.7 Bindings for *"Love filled my heart"* generated by the metaphor template of Figure 4.6

which are then passed to the interpreter for further processing.

4.5 Interpretation Rules

Associated with each metaphor template is an interpretation rule used to translate the bindings generated by the template into an interpretation of the metaphor. The rules use the binding values, tense, and presence of negatives in the input to determine the final form of the interpretation by specifying which print-formats to apply.

A sample rule is shown in Figure 4.8. It specifies that two print-formats should be applied to the bindings (either the `has-mental-thing` format or the `lacks-mental-thing` format and a `description` format), corresponding to the two interpretation assertions associated with this metaphor template. If applied to the bindings of Figure 4.7 for *"Love filled my heart"*, this rule produces the interpretation "`I had Love (Description: filled)`". Note that the parenthetical "`Description`" just preserves portions of the input containing the "essence" of the metaphor. It is included when the interpretation rule does not adequately capture all the subtleties of the metaphor's meaning. In the current rule, the description is bound to the contents of the `?action` variable, which often provides insight into the intensity of an emotion (e.g. *"full"* vs. *"empty"*) or the manner in which an emotion or mental state was acquired or lost (e.g. *"escaped"* vs. *"left"*). This information is an important reason why a CONTAINER metaphor is used, but is difficult to translate effectively.

```
(defassert (let ((person (if (body-part ?object)
                              (get-pronoun ?object)
                            ?object)))
             (if (is-add ?action)
                  (print-assert 'has-mental-thing tns person ?agent)
               (print-assert 'lacks-mental-thing tns person ?agent))
             (print-assert 'description ?action)))
```

"Love filled my heart." → `I had Love (Description: filled)`

Figure 4.8 Sample interpretation rule for the PEOPLE-ARE-CONTAINERS metaphor template of Figure 4.6, and the interpretation it produces for the sentence *"Love filled my heart."*

Interpretation rules are derived from the empirically observed relationships between common meanings of the metaphor and the source characteristics used to convey them (previously described in Section 3.3.2). Collectively, these rules and their associated metaphor templates can be viewed as a definition of the underlying structure or mapping of a metaphor.

As an illustration of this mapping, consider the structure of the PEOPLE-ARE-CONTAINERS metaphor shown in Table 4.2. The first column lists characteristics of the **container** source domain, such as the ability to *open* or *close* a container. In literal descriptions of a container, these characteristics communicate information about the state of a container and its contents (e.g. opening a container alters the *accessibility* of its contents). Analogously, in the metaphoric usage of a container, many of the same characteristics are used to contribute information about the state of our emotions or thoughts. The second column summarizes the target knowledge contributions associated with each characteristic, which serve as the basis of the interpretation rules.

Table 4.2 Mapping for the PEOPLE-ARE-CONTAINERS metaphor.

Container Characteristics	Knowledge Contributed	Corresponding Idea Unit
May be opened or closed by a human agent	*Accessibility* of emotions or thoughts to another person; degree of trust for another person	?action(?agent, ?object) where: ?action ∈ **container-act** (e.g. *"open"*, *"close"*) ?agent ∈ **human** ?object ∈ **body-part**
May have a substance added or removed	Indicates a person's *current state* or notes a *change of state;* may contribute information about the *intensity* of an emotion or *manner* in which the thought or emotion was acquired or lost.	?action(?agent,?object) where: ?action ∈ **container-act** (e.g. *"fill"*, "empty", *"enter"*, *"leave"*) ?agent ∈ **mental-thing** ?object ∈ **body-part** or **human**
Possesses physical characteristics	Depending on the attribute, may describe *intensity* of a person's emotions, their *accessibility* to other people, or their general *mental state.*	?attribute(?possessor) where: ?attribute ∈ **quantity** or **container-attribute** ?possessor ∈ **body-part** or **human**
Holds substance	Person *experiences* a particular emotion or mental state.	?prep(?agent, ?object) where: ?prep ∈ **containment-preposition** ?agent ∈ **human** or **body-part** ?object ∈ **mental-thing**

Finally, the third column lists the corresponding "idea units" for each source characteristic, which are consistent with the metaphor patterns derived from the empirical study.

Note that although the specific syntactic or lexical forms for a metaphor will vary between uses, the basic mapping between source characteristics and target interpretations generally remains invariant. Observe also that although this representation is similar to the metaphor mapping used by previous systems, it operates at a level of abstraction above direct feature mapping between source and target domains: rather than mapping individual words from the source domain to target, we map word categories and idea units to target interpretations. We call this approach to metaphor comprehension a *goal-driven* approach, reflecting the idea that interpretation of a conceptual metaphor can be reduced to identifying the set of specific communicative goals the metaphor is used to satisfy (e.g. communication of an emotion's intensity, or identifying a change in one's mental state).

4.6 The Knowledge Base

As noted earlier, the success of both the recognition and interpretation processes depends critically on the knowledge available to PoEM. To better understand the types of knowledge used, consider again the example of Chapter 2: *"Our relationship is going nowhere"*. Identification of this sentence as an instance of LOVE-IS-A-JOURNEY entails access to:

- *Domain knowledge* – understanding which concepts are related to the **journey** source domain and how they are related (e.g. understanding that a journey typically involves moving towards a destination, and that progress is measured in terms of distance from this location.)
- *Word sense disambiguation* – recognizing which word senses of "relationship" (e.g. a reference to a romantic relationship vs. a reference to a relation between constituent parts) and "going" (as in traveling vs. giving out or failing) are being used.
- *Semantic relations between words* – recognizing that a romantic relationship is related to love and that "going" is a member of the semantic category of **travel-verbs**.

The source domain knowledge is encoded in the metaphor templates and interpretation rules described in the previous two sections. The remaining word sense and semantic relation information used by PoEM is built upon the WordNet database. Rather than taking on the difficult task of word sense disambiguation, PoEM utilizes sense frequency information and the semantic relationships in WordNet to make a "best guess" at the word sense and semantic category of each word in the input. WordNet is also used to define the semantic category constraints on allowable predicates and arguments for metaphor templates.

4.6.1 An Overview of WordNet

WordNet is an electronic lexical database of English developed by researchers at Princeton University [Miller et al. 90]. It covers the four part-of-speech categories generally referred to as "open class" categories: nouns, verbs, adjectives, and adverbs.

{ chair }
SENSE 1: seat

{ professorship, chair }
SENSE 2: position

{ president, chairman, chairwoman, chair, chairperson }
SENSE 3: presiding officer

{ electric chair, chair, death chair, hot seat }
SENSE 4: instrument of execution

Figure 4.9 Four WordNet synsets for noun *"chair"*. Bracketed words represent the synset; a corresponding description is provided in italics below each synset.

Table 4.3 Description of WordNet semantic relations used by PoEM

Name	Description	Part-of-Speech
synonym	Semantic equivalence relation indicating two words have equivalent meanings in a particular context. (e.g. synonyms of *"chair"* include *"president"*, *"chairman"*, *"chairwoman"* and *"chairperson"*)	all
antonym	Semantic opposite relation indicating two words have nearly opposite meanings in a particular context. (e.g. *"cold"* is an antonym of *"hot"*)	all
hypernym	*IS-A* relation designating a super-class (e.g. *"chair"* is a hypernym of *"armchair"*)	noun, verb
hyponym	*A-KIND-OF* relation designating a member of a class (e.g. *"armchair"* is a hyponym of *"chair"*)	noun, verb

The basic unit of organization used in WordNet is the synonym set, or *synset*. Each synset contains a set of words (individual words and word *collocations*) representing a single word sense or meaning. For example, Figure 4.9 lists the four WordNet synsets for the noun *"chair"*, ordered from most to least common word sense: a piece of furniture, a position, a reference to the presiding officer, and an execution instrument. The current release, WordNet 1.6, contains 99,642 synsets representing a total of 173,941 word senses [Miller et al. 97]. This includes 60,557 noun synsets, 11,763 verb synsets, 16,428 adjective synsets, and 3243 adverb synsets.

Individual synsets are linked together by a variety of semantic relations, defining semantic networks for each of the four part-of-speech categories. Nouns are by far the largest and most semantically rich of the four categories in WordNet. Verbs have considerably fewer synsets, but have the second largest number of semantic relations. The semantic relations relevant to the present work are defined in Table 4.3.

Table 4.4 WordNet lexicographic categories for nouns and verbs.

Lexicographic Categories for Nouns

Tops	cognition	food	person	relation
act	communication	group	phenomenon	shape
animal	body	location	possession	state
artifact	event	motive	process	substance
attribute	feeling	natural-object	quantity	time

Lexicographic Categories for Verbs

bodily-care	communication	contact	motion	social-interaction
change	competition	creation	perception	state
cognition	consumption	emotion	possession	weather-verbs

All noun and verb synsets are also classified under one of the 40 different lexicographic categories (25 noun and 15 verb categories) shown in Table 4.4, each representing a different domain of knowledge. Note the "Tops" category for nouns is a special category containing the root synsets of the other 24 noun category hierarchies.

4.6.2 Semantic Category Definitions

The semantic categories used by PoEM during recognition and interpretation are defined from a combination of the lexicographic categories and semantic relations just described. Six different approaches, summarized in Table 4.5, have been taken to specifying these categories. The most general approach uses the WordNet lexicographer categories directly as the semantic categories. This is appropriate for specifying very general semantic categories such as **animate**, which consists of the union of the "animal" and "human" lexicographic categories for nouns. At the opposite end of the spectrum is the approach to defining a semantic category by explicitly listing the set of words to be included. An example is the **containment-prep** category, which lists all prepositions that can be used to indicate a state of *containment*. This degree of specificity is appropriate for very narrow categories and for categories involving parts-of-speech for which WordNet contains little semantic information

Note that semantic categories may be defined using a combination of these approaches, as is done in the full specification of the **mental-thing** category, given in Figure 4.10. This category includes the noun lexicographic categories "cognition", "feeling", and "state" in addition to the hyponyms of the "psychological_feature" and "abstraction" synsets.

Table 4.5 Six approaches to semantic category definition. Lexicographic categories are quoted and prefixed with their associated part-of-speech.

A *semantic category* is defined as one or more of the following:

1. A lexicographic category
   e.g. **animate** = "noun.person" ∪ "noun.animal"

2. All synsets which are hyponyms (subclasses) of a specific synset
   e.g. **mental-thing** =
   { s | $s \in$ **hyponyms**(**synset**("psychological_feature")) }

3. All words assigned a particular part-of-speech tag
   e.g. **proper-name** = { w | **tag**(w) = "NNPS" or **tag**(w) = "NNP" }

4. Synonyms and antonyms of a specific word, each of which is also a member of a particular lexicographic category.
   e.g. **sight-verbs** = { w | $w \in$ **synset**("see") and $w \in$ "verb.change" }

5. Synonyms and antonyms of a specific word-sense.
   e.g. **journey-verbs** = { w | $w \in$ **synset-ID**("01253107") }

6. A manually-specified list of words.
   e.g. **containment-preps** = { *"in" "out" "into" "inside" "outside" "through"* }

mental-thing =
{ s | s ε **hyponyms**(**synset**("psychological_feature"))
or s ε **hyponyms**(**synset**("abstraction"))
or s ε "noun.cognition" ∪ "noun.feeling" ∪ "noun.state" }

Figure 4.10 Definition of the mental-thing semantic category.

4.6.3 Word-Sense Identification

In many cases, knowing which word-sense is being used is a necessary precondition for determining which semantic category that word belongs to. PoEM deals with the problem of word-sense disambiguation by assuming that the word sense for every word in the input is just the most common word-sense of that word in the WordNet database. For example, an occurrence of the word *"chair"* will be treated as an instance of the word-sense meaning *seat.*

4.7 Summary

This chapter has described the design and implementation of PoEM, a prototype system used to recognize and interpret emotion and mental state metaphors in single sentence inputs. Processing in PoEM occurs in three major stages: pre-processing, metaphor recognition, and metaphor interpretation. However, only the latter two of these, recognition and interpretation, are particularly central to the current research.

The recognition and interpretation modules of PoEM implement two key ideas of the current approach to metaphor comprehension. The first is the use of metaphor templates. Because the templates are derived from syntactic and semantic patterns identified in the empirical study of Chapter 3, there is greater likelihood that they reflect actual metaphor use. Moreover, using an implementation based on "idea unit" structure and semantic categories should give PoEM greater capacity to recognize lexical and syntactic variations occurring in individual metaphor, providing better coverage of new instances as well as the ability to recognize multiple metaphors.

The second key idea is the interpretation rule, which reflects a goal-driven approach to comprehension. By pre-identifying common communicative goals underlying descriptions of emotions and mental states, we produce interpretations which are not just simple word substitutions of a metaphor with its "literal equivalent". The potential drawback is that it is difficult to predict and model all the lexical and syntactic variations of metaphor necessary to capture the subtleties of individual instances. For this reason, interpretations include direct excerpts from the input which are likely to contain information important to the "essence" of a metaphor.

One of the objectives of this work was to develop an empirically well-founded approach to metaphor-comprehension. PoEM achieves this goal by demonstrating an approach that uses empirical evidence as a guide throughout the design and implementation process. A second objective was to develop an extensible base for practical implementations of metaphor comprehension. This goal has been achieved to a somewhat lesser extent by the current prototype. The modular design makes replacing or augmenting existing metaphor coverage a relatively straightforward matter of defining new templates, interpretation rules, and any additional semantic categories they require. Unfortunately, although it is relatively easy to implement, there is significant effort involved in performing the supporting empirical analysis.

Additionally, although WordNet is useful, it is not perfect, and defining semantic categories is a trial-and-error process requiring familiarity with WordNet's strengths and idiosyncracies.

There are also a number of obvious shortcomings in the current implementation, particularly the relatively primitive phrasing provided by the pre-processor and lack of genuine word-sense-disambiguation. Because each of these tasks is by itself a difficult problem, and neither is particularly central or unique to the issue of metaphor comprehension, only the minimum effort was spent on their implementation. However, because they can have a large effect on the overall performance of the system, they must be improved upon before the system can really be considered for practical applications.

Additionally, a context model can aid in both recognition and interpretation even for metaphors constrained to a single sentence by providing additional information about the current topic and focus of the conversation. Having this information may make it easier to figure out what kinds of metaphors are most likely to occur, helping to focus the search for specific constituents containing important information.

A third issue is how interpretations of input sentences containing multiple metaphors should be constructed. PoEM has made the simplifying assumption that these can be analyzed piecemeal, with the overall interpretation equal to the combined interpretations of its constituent metaphors. While it appears to be a reasonable assumption for some of the simpler metaphors under consideration here, whether or not this is in general a good practice remains to be seen.

5 Conclusion

This final chapter presents a preliminary evaluation of the PoEM system, followed by a discussion of possible enhancements to PoEM and future research directions. We close with a summary of the primary contributions of this thesis and its relationship to ongoing work.

5.1 Preliminary Evaluation of PoEM

To provide some sense of how well the prototype system works, and its specific strengths and weaknesses, a preliminary evaluation was performed to test PoEM's recognition accuracy on both positive and negative examples.

Note that for this preliminary evaluation, we have chosen to focus solely on evaluating the effectiveness of the metaphor templates and semantic categories. The reasons for doing this are twofold. First, the recognition process really constitutes the core of the system. If we cannot successfully identify if and which metaphor is present, then we have no hope of producing a suitable interpretation with the current approach . Second, although it is easy to provide quantitative assessment of the recognition performance, it is much more difficult to do for the interpretations it produces, pariticularly in the absence of an application in which to assess the value of the information contributed by PoEM. For these reasons, a formal evaluation of the interpretation rules has been deferred to future work.

The objective of the recognition module evaluation was to assess how effectively the metaphor templates and semantic category representations could identify instances of metaphors. In particular, we were interested in determining:

- The percentage of metaphor instances recognized.
- Whether or not the templates over-generalize, and if so for which kinds of inputs.
- Which metaphors are successfully matched via templates, and which are the least successful.
- The most common reasons for recognition errors.

5.1.1 Methodology

For simplicity, the data from the hand-sampling study was used as the test set to evaluate recognition performance. Since the metaphor templates were derived from both the hand-sampling and directed search studies, using this data seemed like a reasonable way to estimate an upper bound for the recognition accuracy of PoEM. It also had the advantage of being pre-tagged for all metaphor occurrences, which greatly reduced the amount of effort required to carry out the evaluation.

Both positive and negative examples were presented to PoEM, and recognition accuracy was determined by computing the number of correct and incorrect classifications for each. All examples used during the evalution were drawn from metaphor instances identified during hand-sampling. After serving as a positive test for its own metaphor group, each instance was then used as a negative example to test the rejection capabilities of the other metaphor templates.

Any metaphor correctly classified for the wrong reasons is considered a false positive. Likewise, any metaphors missed due to errors in the pre-processing of the input or examples beyond the scope of the current system are false negatives.

5.1.2 Results

The results of testing PoEM on instances from the five metaphor groups are summarized in Table 5.1. The total number of templates that PoEM contains for each metaphor group is listed in the second column. The third and fourth columns list the number of positive and negative examples on which the template sets were tested. The number of true positive and negative classifications, and false positive and negative classifications are listed in the fifth through eighth columns respectively.

Table 5.1 Summary of recognition results for PoEM.

Metaphor Group	Total Templates	+ Ex	- Ex.	True +	True -	False +	False -
Object/Possession	8	128	112	22 (17%)	105	13	100 (78%)
Journey	7	67	120	8 (12%)	116	4	59 (88%)
Container	5	46	121	8 (17%)	121	1	37 (80%)
Proximity	2	44	130	0 (0%)	128	2	44 (100%)
Vision	7	32	137	4 (12%)	132	5	28 (88%)

At first glance, the recognition of PoEM is disappointing, and somewhat puzzling. The best recognition was for metaphors in the POSSESSION and CONTAINER categories (with 17% recognized). The worst of the five was the PROXIMITY group for which no matches were generated. Also surprising was the poor VISION metaphor recognition (12%), considering this was probably the most lexicalized of any of the groups.

However, upon closer analysis, the causes of the failures for each metaphor group are somewhat more encouraging, and certainly informative. Many of the instances that were not identified as metaphors contained either syntax that was not adequately modeled by the pre-processing routines, or a tagging error which resulted in a semantic category mis-match.

Another problem common to all metaphor groups is that of ambiguity in the input. In a number of instances, it was impossible to tell from the input provided whether or not the sentence was metaphoric (e.g. *"I was lost"* or *"I've come so far."*). Here, PoEM's failure to recognize these instances as metaphors is really the appropriate response, given that we probably don't want to be overly-eager to recognize all input as metaphoric.

Many of the missed VISION metaphors were caused by sentences of the form "*<person> <see> (that; what) <clause>*". PoEM is currently designed only for single sentence inputs, and will analyze any relative clauses separately. Moreover, the current semantic categories are lexical concepts; there no way for PoEM to perform a "meta-level" analysis of the clause to determine whether or not it is talking about something tangible (e.g. *"I saw that the dog had torn my slippers to shreds."*) versus an abstract thought or emotion (e.g. *"I see that you will never be mine."*).

Other causes of error identified include: not having a template which covered the syntactic form used by the input sentence, semantic categories which were either too narrow or too broad, and mistakes in the template specification. These latter errors were reason the PROXIMITY metaphor recognition was non-existant, and point to another important aspect of the current implementation: developing the templates is an iterative process; even if the specifications are determined entirely from the empirical data, there is still a lot of opportunity to introduce error, and some debugging after implementation is almost inevitable, particularly with the semantic category specifications.

5.2 Future work

5.2.1 Enhancements to PoEM

The evaluation results of PoEM's current recognition capability highlight the need for a number of improvements to the system.

The first and most obvious of these is to improve the pre-processing routines used by PoEM. It is difficult enough to extract the relevant information from the input given perfect pre-processing; without it, extracting the information can be impossible.

The system should also be expanded to include sentence boundary detection, anaphora resolution, and a discourse model. This would give PoEM the flexibility to consider metaphors extending beyond a single sentence, as well as give it access to more information during the recognition and interpretation stages.

As implemented, metaphor templates assume that only one component of an idea unit will be a metaphoric usage and the others will be used literally. If the sentence contains a metaphor as one of the template arguments or a relative clause as described in the previous section, PoEM will fail to identify the current usage as metaphoric. For example, a PEOPLE-ARE-CONTAINERS template requiring a member of the **mental-thing** category can not recognize a metaphoric or clausal reference to an emotion (i.e. use of the word *"blue"* in place of *"sorrow"*). This is not necessarily an easy problem to solve, but one which merits further study.

Once these improvements are made, a more rigorous evaluation of PoEM should be performed within the context of a specific application, to re-evaluate the recognition performance as well as to assess the effectiveness of the output generated by the interpretation rules.

5.2.2 Open Issues

In addition to the specific enhancements to PoEM, there are many other aspects of metaphor comprehension which are still open issues. A few of the more critical of these are described briefly below.

- **Improved characterization of the communicative role of metaphor and relative ordering of concepts within semantic categories.**
  One of most important requirements for metaphor comprehension is having a good understanding of the communicative functions metaphors serve. Although the empirical study presented here has identified several common communicative goals for mental states and emotions, these are just the top level goals for one domain. We need to identify analogous goals for each domain of interest. Additionally

an interpretation system needs to understand the relative ordering that is applied to members of a particular semantic category, and how that ordering relates to the range of interpretations possible within a particular communicative function. For example, suppose we wished `to communicate how well (the *manner* in which) one is currently progressing in life. When presented with a sentence containing this information via a JOURNEY metaphor, even when PoEM is able to identify which metaphor we are currently dealing with and mark the verb material as containing important information about the interpretation, it still has no way of determining whether *crawling* is better or worse than *running* or *flying*, knowledge which is critical to the final interpretation of the metaphor.

- **Reasoning about metaphor combinations**
  As previously noted, it is possible for PoEM to identify more than one metaphor within a single sentence, because it tries to match as many templates as possible. However, each match is handled independently of any other it finds; PoEM does not try to unify the roles of each metaphor to produce an integrated interpretation or check that no contradiction exists between them. While this is obviously a simplification, it remains to be seen whether or not this is a reasonable simplification for most metaphors we encounter.

- **Recognizing metaphor at multiple levels**
  Both cognitive and computational research has focused almost exclusively on the word through sentence levels of interpretation. However, if we wish to analyze longer text documents, we will need to characterize "higher level" metaphors found at the paragraph or story level as well. Each requires different representations of information content, different mechanisms to identify metaphoric occurrences, and will also require additional reasoning capabilities to ensure their collective interpretations form a consistent whole.

- **Learning new metaphors and interpreting novel metaphors**
  Because of the time involved in encoding knowledge about a particular metaphor into the system, it would be very beneficial if we could automatically add new metaphor to the existing knowledge base, possibly using an analogical framework that would be useful for interpreting novel metaphors as well. There has been some preliminary work in this area, namely the MIDAS Metaphor Extension System (MES) [Martin 90], that successfully learned variants of known metaphors. However, MES was unable to handle completely novel metaphors, and did not address the issue of how to decide when to add a metaphor to the knowledge base (in MES they were always added). If statistical or connectionist approaches prove feasible, they may help alleviate this problem.

- **Alternate approaches to metaphor recognition**
  In a similar vein, given that we now have a small corpus containing tagged examples of metaphors, is it possible to apply machine learning techniques to the task of metaphor identification? It would

be interesting to compare the recognition achieved with metaphor templates to that achieved by applying decision tree or rule learning to the same data. Studying the features they use to recognize the metaphors may provide valuable insight into the structure of metaphor, and if successful, could simplify the development process significantly, letting the developer focus efforts on interpretation.

- **Development of metaphor corpora and analysis tools**
  One of the biggest obstacles to using empirical data to guide the implementation process is the dearth of labeled electronic corpora, and the large time investment required to analyze or hand-label the data. It would be extremely helpful to have analysis tools such as a metaphor tagger that could help tag metaphor automatically. Even if not perfect, it would still provide significant time savings.

- **Metaphor generation**
  Lastly, it would also be quite interesting to see how well the current approach can be applied to the problem of metaphor *generation*. To date, no one has really considered how to generate metaphors, despite the wealth of research on interpretation. Moreover, it would be an interesting way to evaluate how well the current interpretation scheme works.

5.3 Summary

This thesis has presented a *characterization* of metaphor through empirical analysis, and a *computational approach* based on this characterization, focusing specifically on common conceptual metaphors for emotions and mental states. Using this approach, we have implemented PoEM, a prototype system which uses metaphor templates, interpretation rules, and semantic knowledge derived from WordNet to interpret single sentence inputs containing metaphors.

5.3.1 Contributions

The primary contributions of this thesis are:

- An empirical study extending our knowledge about conceptual metaphors for emotions and mental states, and an accompanying tagged corpus of song lyrics.
- A computational approach and evaluation methodology based on a goal-driven approach emphasizing the communicative functions served by conceptual metaphors
- A prototype system which can be used in future research, either as a component within a larger NLP system, or as a tool for additional corpus-based analysis of metaphors.

5.3.2 Relationship to other work at the Media Laboratory

As with most research, the present work has benefited from and been influenced by the efforts of others, notably, other members in the Machine Understanding Group. PoEM's current interface to WordNet 1.6 is an extension of work done for ImEngine and NetSurf, two applications exploring use of semantic background knowledge for information retrieval [Chakravarty 95]. Some of the inspiration to use pattern matching techniques came from SpinDoctor [Sack 94], a system which identified ideological point-of-view in news stories using "actor role analysis".

The current work has also been motivated by a desire to support ongoing research areas at the Media laboratory. Metaphor comprehension is of obvious relevance to research in story understanding and may prove beneficial to other research in which information about our thoughts, emotions, and possibly beliefs or ideological point-of-view, needs to be extracted from linguistic data. Additionally, as we consider how to make computer systems more expressive (in the aesthetic sense), having an improved understanding of how we use metaphor to convey our emotions and ideas is certain to be of value.

Appendix A

Summary of the lyrics corpus by genre and artist.

Genre: Alternative

Artist	Songs	Words
Alanis Morisette	10	2184
Ben Folds Five	10	2117
Depeche Mode	11	1544
Fiona Apple	10	2248
Live	10	1468
Nine Inch Nails	11	3195
Paula Cole	14	2041
Pearl Jam	23	3177
Sheryl Crow	17	3955
Tracy Chapman	10	2484

Genre: Country

Artist	Songs	Words
Clint Black	22	4185
Emmylou Harris	19	3097
Garth Brooks	11	2494
George Strait	15	2480
Gram Parsons	10	1850
LeAnn Rimes	21	3659
Lee Ann Womack	11	1950
Lonestar	15	3755
Mary Chapin Carpenter	18	4311
Mindy McCready	10	2351
Reba McEntire	14	3156
Vince Gill	8	1051

Genre: Blues

Artist	Songs	Words
Bessie Smith	11	2281
Big Bill Broonzy	15	2959
Billie Holiday	3	439
Champion Jack Dupree	10	2345
Eddy Clearwater	4	713
Ella Fitzgerald	4	480
Jeannie and Jimmy Cheatham	9	1133
John Lee Hooker	8	1563
Lightnin' Hopkins	24	3858
Little Walter	6	905
Louis Armstrong	14	1926
Muddy Waters	15	2219
Ray Charles	6	1224
Sonny Boy Williamson	11	1588

Genre: Easy Listening

Artist	Songs	Words
Barbara Streisand	11	2169
Barry Manilow	13	2372
Basia	10	1673
Billy Joel	19	5239
Celine Dion	15	3894
Elton John	15	2381
Fleetwood Mac	11	1290
Journey	11	1622
Michael Bolton	10	2363
REO Speedwagon	16	2690
Sade	12	2643
Seal	9	2896
Toni Childs	23	4413

Appendix B

Summary of metaphors found in the lyrics corpus and corresponding abbreviations used to tag the corpus. (✓ = emotion or mental state metaphor; ✣ = related metaphor, often used in descriptions of emotions/mental states; blank = other)

Included?	Abbrev.	Metaphor
✓	AAP	ANGER AS PREDATOR
✣	AAW	ARGUMENT AS WAR
	AHC	ACTION HAS COST
✓	BAO	BELIEF AS OBJECT
✓	BEAC	BAD EMOTIONS AS CAPTORS
✓	BFAF	BAD THOUGHTS/FEELINGS ARE OPPRESSIVE FORCES
✓	BIB	BELIEVING IS BUYING/SELLING IDEAS
✓	BID	BAD/SAD IS DARK
	BIH	BONE IS HANDOUT/CONCESSION TO LESS FORTUNATE
✣	BPAD	EVIL PERSON IS A DEVIL
✓	BRAC	BAD EMOTION/RELATIONSHIP AS CAPTOR
✓	BTAC	BAD THOUGHTS ARE CAPTORS
✓	BTAP	BAD THOUGHTS/DREAMS ARE PREDATORS
✓	CAO	CHANCE IS OBJECT
	CAP	COUNTRY AS PERSON
✣	CII	CENTRAL IS MOST IMPORTANT
✓	DAO	DREAMS AS OBJECTS
✓	DAPO	DREAMS AS POSSESSIONS
	DIBP	DISTANCE AS MEASUREMENT OF MONEY'S BUYING POWER
	DID	ONSET OF DARKNESS IS DEATH/SLEEP
✓	DIF	DARKNESS = CONFUSION/FEAR
✓	DIH	DESIRE IS HUNGER
✣	DIM	DEEPER THE GREATER
✓	EACO	EMOTION IS COLOR
✓	EACL	EMOTIONS ARE CLOTHES
✓	EAC	EYES AS CONTAINER FOR THOUGHT/EMOTION
✓	EAF	EMOTIONAL ATTRACTION IS A PHYSICAL FORCE
✓	EALO	EMOTION AS LIVING THING
	EAMO	EVENT AS MOVING OBJECT
✓	EAO	EMOTION AS OBJECT
✓	EAP	EMOTION AS PERSON
✓	EAPO	EMOTION AS POSSESSION
✓	EAS	EMOTION AS SUBSTANCE
✓	EFPF	EMOTIONAL/SPIRITUAL FREEDOM IS PHYSICAL FREEDOM

Included?	Abbrev.	Metaphor
✓	EHP	EMOTIONAL HARM IS PHYSICAL HARM
✓	EIF	EMOTIONAL INSTABILITY/VULNERABILITY IS FALLING
✓	EIFI	ATTRACTION/INTEREST IS FIRE/SPARK
✓	EII	EXPERIENCING IS INGESTING
	EVMO	EVENTS ARE MOVING OBJECTS/FORCES
	FAO	FAMILY AS OBJECT
✓	FAP	FEAR AS PERSON
✓	FAPO	FREEDOM AS POSSESSION
	FAS	FAMILY AS STRUCTURE
✓	FIC	COLD IS FEAR
✓	FIF	FAILURE IS FALLING
✓	FIFL	FREEDOM IS FLIGHT
✓	FIR	FREEDOM IS RUNNING
	FSPS	FINANCIAL STABILITY AS PHYSICAL STABILITY
	GALO	GROUP AS LIVING OBJECT
✓	GAP	GOAL AS PLACE
	GAPO	EARTH AS POSSESSION
✓	GIL	GOAL IS LIGHT
✣	GRPC	GOOD RELATIONSHIP -> PHYSICAL CLOSENESS
✓	HAC	HEART AS CONTAINER FOR LOVE
✣	HAFO	HEART AS FRAGILE OBJECT
✓	HAL	HEART AS LOVE
✣	HAMO	HEART AS MECHANICAL OBJECT
	HAM	HOROSCOPE AS SUBSTANCE/MEDICINE
✓	HAO	HEART AS CONNECTING OBJECT
✣	HAP	HEART AS PERSON
✣	HAPO	HEAD AS POSSESSION
✓	HALO	HATRED AS LIVING THING
✓	HIA	WARMTH/HEAT IS ALIVE
✓	HIL	HAPPY IS LIGHT
✓	HIM	HAPPY IS PLAYING MUSIC
✣	HIP	INSIDE IS HIDDEN/PROTECTED
✓	HIS	HAPPY IS SINGING
✓	HIST	STARS/SKY REPRESENTS HOPES/GOALS/DREAMS
✓	HIU	HAPPY IS UP
✓	HOIL	HOPE IS LIGHT
✓	HOIU	HOPE IS UP
✣	HSIU	HIGHER STATUS IS UP
✓	IAC	IDEA AS DIFFERENT COLOR
✓	IAO	IDEA AS OBJECT
	IAP	INSTRUMENT AS PERSON
✓	IAPO	IDEA AS POSSESSION
✓	IBW	INVOLVEMENT IS BEING IN WATER
✓	ING	INTOXICATION IS NOT TOUCHING GROUND

	JAS	JUSTICE AS BUILDING/STRUCTURE
✣	LAB	LIFE AS BATTLE

Included?	Abbrev.	Metaphor
✣	LABT	LIFE/RELATIONSHIP AS BUSINESS TRANSACTION
✣	LAC	LIFE AS CONTAINER
✓	LACO	LOVE AS CONSTRUCTED OBJECT
✓	LAD	LOVE AS ILLNESS/DISEASE
✓	LAF	LOVE IS A FORCE
✓	LAG	LIFE/LOVE AS GAMBLE
✣	LAJ	LIFE AS JOURNEY
✓	LAM	LOVE AS MEDICINE
✓	LAMO	LOVE AS MOVING OBJECT/WEAPON/BULLET
✓	LAP	LOVE AS PERSON
✓	LAPO	LOVE AS POSSESSION
✣	LAQ	LIFE AS QUEUE
✓	LAS	LOVE AS SUBSTANCE
✣	LAT	LIFE AS THREAD/ROPE
✣	LIACO	LIFE AS CONSTRUCTED OBJECT
✣	LIAG	LIFE AS GAMBLE
✣	LIAMO	LIFE AS MOVING OBJECT
✣	LIPE	LIFE AS PERFORMANCE
✣	LIAP	LIFE AS PERSON/FORCE
✣	LIAS	LIFE AS SUBSTANCE
✣	LIC	LIFE AS RESOURCE
✣	LID	LIVING IS DANCING
✓	LIFI	LOVE IS FIRE
✓	LIH	LUST IS HEAT
✓	LII	LOVE IS INTOXICANT
✓	LIL	LOVE IS LIGHT
✓	LIM	LOVE AS MAGIC
✣	LLP	LIFE AS LINEAR PATH
✓	LPAP	LOVED ONE AS POSSESSION
✓	LVP	LIGHT INDICATES VIEWPOINT
✓	MAC	MIND AS CONTAINER
✓	MACO	MIND AS CONSTRUCTED OBJECT
	MAF	MOTHERHOOD AS FARMING
✓	MAM	MIND AS MECHANICAL PLAYER
✓	MAO	MEMORY AS OBJECT
✓	MAP	MEMORY AS PERSON
✓	MAPA	MENTAL ABUSE IS PHYSICAL ABUSE
✓	MAPM	MENTAL/EMOTIONAL MATURITY AS PHYSICAL MATURITY
✓	MHP	MENTAL HEALTH IS PHYSICAL HEALTH
✓	MIS	MENTAL INSTABILITY/CONFUSION IS SPINNING
	MOAP	MOON AS PERSON
✓	MPPP	MENTAL PRESENCE AS PHYSICAL PRESENCE
✓	OAG	OPPORTUNITIES AS GIFTS
✓	OAMO	OPPORTUNITY AS MOVING OBJECT

✓	OCT	TRUSTING = OPEN CONTAINER
✓	OM	ON MIND

Included?	Abbrev.	Metaphor
	PAA	PERSON AS ANIMAL
✓	PAC	PERSON AS CONTAINER FOR EMOTION/THOUGHT
✣	PAFO	PERSON AS FRAGILE OBJ
✓	PRFO	PROMISE AS FRAGILE OBJECT
✓	PAG	PROBLEMS/BAD MEMORIES ARE GHOSTS
	PAM	PERSON AS MACHINE
	PAO	PERSON AS OBJECT
	PAS	PERSON AS STRUCTURE
✓	PBM	PHYSICAL BOUNDARY (LINE) FOR MENTAL BOUNDARY (THOUGHT/IDEAS)
✓	PIC	POSSESSION/CONTAINMENT IS CONTROL
	PIIO	PERSON AS INANIMATE OBJECT
✓	PIH	PASSION IS FEVER
	PIM	PERSON IS MUSIC
✓	PTEA	PHYSICAL TOUCH AS MENTAL/EMOTIONAL ASSISTANCE
✣	RAB	RELATIONSHIP AS BATTLE
✣	RAC	RELATIONSHIP AS CONSTRAINT
✣	RAD	FAILING RELATIONSHIP AS DISEASE REQUIRING TREATMENT
✓	RAJ	RELATIONSHIP/LOVE AS JOURNEY
✣	RALO	RELATIONSHIP AS PLANT/LIVING OBJECT
✓	RAMO	RESPONSIBILITY AS OBJECT MOVING TOWARD PERSON
	RAO	RULE AS OBJECT
✣	RAS	RELATIONSHIP AS STRUCTURE
✣	RIB	RELATIONSHIP IS BOOK/STORY
✓	RIL	REMEMBERING AS ILLUMINATION
✓	RIU	REASON IS UP
✣	RLP	RELATIONSHIP AS LINEAR PATH
✓	SAC	STATE AS CONTAINER
✓	SACO	MENTAL STATE AS CONSTRUCTED OBJECT
✓	SAEE	SONG AS EXPRESSION OF EMOTION (USU. HAPPY)
	SAF	STARS AS FORTUNE
✓	SAO	STATE AS OBJECT
✓	SAP	STATE AS PLACE
✓	SAPO	STATE AS POSSESSION
✓	SCL	STATE CHANGE = LOCATION CHANGE
✓	SEAP	SECRETS AS PEOPLE
✓	SEPD	STRENGTH OF EMOTIONAL EFFECT = PHYSICAL DISTANCE
	SES	SEA = SKY
✓	SIB	SADNESS IS BLUE
✓	SID	SAD IS DOWN
✓	SIG	MENTALLY STABLE IS TOUCHING GROUND
	SIM	MUSIC TELLS STORY
✓	SIU	SEEING IS UNDERSTANDING
	SKAP	SKIN PERSONIFIED
✓	SMAG	SAD MEMORIES AS GHOSTS

	SPAP	SPIRIT AS PERSON

Included?	Abbrev.	Metaphor
	STAP	STARS & NUMBERS PERSONIFIED
✓	STSS	SHARED THOUGHTS/EMOTIONS = SHARING PHYSICAL SPACE
	TAC	TIME AS CONTAINER
✓	TAD	BAD THOUGHTS/EMOTION AS DISEASE
✓	TAJ	THOUGHT AS JOURNEY
	TALO	TIME AS LIVING THING
✓	TAMO	THOUGHT AS MOVING OBJECT
✓	TAO	THOUGHT AS OBJECT
	TAP	TIME/EVENT AS PLACE
✓	TAS	THOUGHTS AS SUBSTANCE/FLUID
	TIAMO	TIME AS MOVING OBJECT
	TIAO	TIME AS OBJECT
	TIC	TIME AS COMMODITY
✓	TRAO	TRUTH AS OBJECT
✣	UILS	UNDERGROUND IS LOW STATUS
✓	VST	FIELD OF VIEW IS SCOPE OF THOUGHTS
✣	WAMO	WORDS AS MOVING OBJECTS
✣	WAO	WORDS AS OBJECTS
	WAS	WORLD AS STRUCTURE
✣	WAW	WORDS AS WEAPONS

Appendix C

Metaphor groups by source domain (see Appendix C for abbreviation descriptions).

Source Domain	Members
activity	FIFL, FIR, LID
book	RIB
captor	BEAC, BRAC, BTAC, EFPF, RAC
centrality	CII, DIM
clothing	EACL
color	EACO, IAC, SIB
commodity	BIB, LIC, TIC
construct	LACO, LIACO, MACO, SACO
container	EAC, HAC, HIP, LAC, MAC, OCT, PAC, SAC, TAC
cost	AHC
disease	LAD, TAD
farming	MAF
fire	EIFI, LIFI, LIH
forces	BFAF, EAF, EVMO, LAF
gambling/games	LAG, LIAG
ghosts	PAG, SMAG
health	HAM, LAM, MHP, RAD
ingestion	DIH, EII
journey	LAJ, RAJ, TAJ
light	BID, DID, DIF, HIL, HOIL, GIL, LIL, RIL
living thing	EALO, HALO, RALO
machine	HAMO, MAM, PAM
magic	LIM
miscellaneous	BPAD, DIBP, LABT, LII, MAPA, MAPM, OAG, UILS, PBM, TAS, SAF, SES, BIH
music	HIM, HIS, SAEE, SIM
non-person as person	CAP, EAP, FAP, GALO, HAP, IAP, LAP, LIAP, MAP, MOAP, SEAP, SKAP, SPAP, STAP, TALO
object/possession	BAO, CAO, DAO, DAPO, EAMO, EAO, EAS, FAO, HAFO, HAO, IAO, LAS, LIAMO, LIAS, MAO, OAMO, PAO, PRFO, RAMO, RAO, SAO, TAMO, TAO, TIAMO, TIAO, TRAO, WAMO, WAO
on	OM
orientation	HIU, HOIU, HSIU, SID, RIU
path	LLP, RLP
performance	LIPE
person as animal	PAA
person as inanimate	PAFO, PIIO, PIM

Source Domain	Members
place	SAP, SCL, TAP, GAP
possession	EAPO, FAPO, GAPO, HAL, HAPO, IAPO, LAPO, LPAP, SAPO
predator	AAP, BTAP
proximity	GRPC, MPPP, PIC, PTEA, SEPD, STSS
queue	LAQ
sky	HIST
stability	EIF, FIF, ING, MIS, SIG
structure	FAS, FSPS, JAS, PAS, RAS, WAS
temperature	FIC, HIA, PIH
thread	LAT
vision	LVP, SIU, VST
war	AAW, LAB, RAB
water	IBW
weapons	EHP, LAMO, WAW

References

Barnden, J. (1992) Belief in Metaphor: Taking Commonsense Psychology Seriously. *Computational Intelligence, 8(3),* 520-552.

Barnden, J., Helmreich, S., Iverson, E. and Stein, G. (1994) An integrated implementation of simulative, uncertain and metaphorical reasoning about mental states. In J. Doyle, E. Sandewall & P. Torasso (Eds.), *Principles of Knowledge Representation and Reasoning: Proceedings of the Fourth International Conference*, 27-38. San Mateo, CA: Morgan Kaufmann.

Baayen, R. H., Piepenbrock R. and Gulikers, L. (1995) The CELEX Lexical Database (CD-ROM). Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA, 1995.

Beckwith, R., and Miller, G. A. (1990) Implementing a lexical network. *International Journal of Lexicography, 3(4),* 302-312.

Black, M. (1979) More About Metaphor. In A. Ortony (Ed.), *Metaphor and Thought*. Cambridge, U.K.: Cambridge University Press.

Brill, E. (1994) Some Advances in Transformation-Based Part of Speech Tagging. In *Proceedings of the Twelfth National Conference on Artificial Intelligence, AAAI-94* (Seattle, WA), 722-727.

Burnage, G. (1990) *CELEX - A Guide for Users*. Nijmegen: Centre for Lexical Information, University of Nijmegen.

Cacciari, C. and Tabossi, P. (1993) *Idioms: Processing, Structure, and Interpretation*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Carbonell, J. G. (1982) Metaphor: An Inescapable Phenomenon in Natural-Language Comprehension. In W. G. Lehnert & M.H. Ringle (Eds.), *Strategies for Natural Language Processing*, 415-434. Hillsdale, NJ: Lawrence Erlbaum Associates.

Chakravarthy, A. (1995) *Information Access and Retrieval with Semantic Background Knowledge*. Ph.D. Thesis, MIT Media Laboratory, Cambridge, MA.

Chin, D. N. (1992) PAU: Parsing and Understanding with Uniform Syntactic, Semantic, and Idiomatic Representations. *Computational Intelligence, 8(3),* 456-476.

Fainsilber, L. and Ortony, A. (1987) Metaphorical Uses of Language in the Expression of Emotions. *Metaphor and Symbolic Activity, 2(4),* 239-250.

Falkenhainer, B., Forbus, K., and Gentner, D. (1986) The Structure-Mapping Engine. In *Proceedings of the American Association for ArtificialIntelligence* (Philadelphia, PA), 272-277.

Fass, D. and Wilks, Y. (1983) Preference Semantics, Ill-Formedness, and Metaphor. *American Journal of Computational Linguistics, 9(3-4),* 178-187.

Fass, D. (1991) met*: A Method for Discriminating Metonymy and Metaphor by Computer. *Computational Linguistics, 17(1),* 49-90.

Fass, D. (1994) A Computer Method for Recognizing Metaphors in Sentences. In *Research in Humanities Computing 3, Selected Papers from the ALLC/ACH Conference, Tempe, Arizona, March 1991,* 127-144. Oxford: Clarendon Press.

Fauconnier, G. and Turner, M. (1994) *Conceptual Projection and Middle Spaces.* Technical Report 9401, Department of Cognitive Science, University of California, San Diego.

Fauconnier, G. (1997) *Mappings in Thought and Language.* Cambridge, U.K.: Cambridge University Press.

Gentner, D. (1983) Structure-Mapping: A Theoretical Framework for Analogy. *Cognitive Science, 7(2),* 155-170.

Gerrig, R. (1989) Empirical Constraints on Computational Theories of Metaphor: Comments on Indurkhya. *Cognitive Science, 13,* 235-241.

Gibbs, R. (1989) Understanding and Literal Meaning. *Cognitive Science, 13,* 243-251.

Glucksberg, S. and Keysar B. (1990) Understanding Metaphorical Comparisons: Beyond Similarity. *Psychological Review, 97(1),* 3-18.

Grice, P. (1989) *Studies in the Way of Words.* Cambridge, MA: Harvard University Press.

Hobbs, J. R. (1983) Metaphor Interpretation as Selective Inferencing: Cognitive Processes in Understanding Metaphor. *Empirical Studies of the Arts.* Reprinted in *Literature and Cognition* (1990), 51-81. CSLI.

Holyoak, K. and Thagard, P. (1995) *Mental Leaps: Analogy in Creative Thought.* Cambridge, MA: MIT Press.

Honeck, R. (1996) Introduction: Figurative Language and Cognitive Science - Past, Present, and Future. *Metaphor and Symbolic Activity, 11(1),* 1-15.

Indurkhya, B. (1987) Approximate Semantic Transference: A Computational Theory of Metpahors and Analogies. *Cognitive Science, 11,* 445-480.

Indurkhya, B. (1994) A Computational Perspective on Similarity-Creating Metaphors. In *Research in Humanities Computing 3, Selected Papers from the ALLC/ACH Conference, Tempe, Arizona, March 1991,* 145-162. Oxford: Clarendon Press.

Johnson, A. (1996) Comprehension of Metaphors and Similes: A Reaction Time Study. *Metaphor and Symbolic Activity, 11(2),* 145-159.

Katz, A. (1996) Experimental Psycholinguistics and Figurative Language: Circa 1995. *Metaphor and Symbolic Activity, 11(1),* 17-37.

Lakoff, G. and Johnson, M. (1980) *Metaphors We Live By.* Chicago, IL: University of Chicago Press.

Lakoff, G., Espenson, J., and Schwartz, A. (1991) *Master Metaphor List: Second Draft Copy.* (on-line database) Cognitive Linguistics Group, University of California at Berkeley.

Lytinen, S., Burridge, R. and Kirtner, J. (1992) The Role of Literal Meaning in the Comprehension of Non-Literal Constructions. *Computational Intelligence, 8(3),* 416-432.

Marcus, M., Santorini, B. and Marcinkiewicz, M. (1993) Building a Large Annotated Corpus of English: the Penn Treebank. *Computational Linguistics, 19,* 313-330.

Martin, J. H. (1990) *A Computational Model of Metaphor Comprehension.* New York: Academic Press.

Martin, J. H. (1994) Metabank: A Knowledge-Base of Metaphoric Language Conventions. *Computational Intelligence, 10(2).*

Miller, G. A., Beckwith, R., Fellbaum, C., Gross, D. and Miller, K. J. (1990) Introduction to WordNet: an on-line lexical database. *International Journal of Lexicography, 3(4),* 235–244.

Miller, G. (1997) *WordNet 1.6 Reference Manual.* (on-line document) Cognitive Science Laboratory, Princeton University, Princeton, NJ, 1997. Available from: http://www.cogsci.princeton.edu/~wn/doc/

Narayanan, S. (1997) *Knowledge-based Action Representations for Metaphor and Aspect (KARMA).* Ph.D. Thesis, University of California at Berkeley, Berkeley, CA.

Norvig, P. (1992) *Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp.* San Francisco, CA: Morgan Kaufmann.

Ortony, A. (1979) The Role of Similarity in Similes and Metaphors. In A. Ortony (Ed.), *Metaphor and Thought.* Cambridge, U.K.: Cambridge University Press.

Ortony, A. (1993) *Metaphor and Thought, Second Edition.* Cambridge, U.K.: Cambridge University Press.

Pollio, H. R., Smith, M. K., and Pollio, M. R. (1990) Figurative Language and Cognitive Psychology. *Language and Cognitive Processes, 5(2),* 141-167.

Roberts, R., and Kreuz, R. (1994) Why Do People Use Figurative Language? *Psychological Science, 5(3),* 159-163.

Santorini, B. (1990) *Part-of-Speech Tagging Guidelines for the Penn Treebank Project (3rd revision, 2nd printing, February 1995)* Working paper, Computer and Information Science Department, University of Pennsylvania, PA.

Sack, W. (1994) *Actor-Role Analysis: Ideology, Point of View and the News.* M.S. Thesis, MIT Media Laboratory, Cambridge, MA.

Searle, J. (1979) Metaphor. In A. Ortony (Ed.), *Metaphor and Thought.* Cambridge, U.K.: Cambridge University Press.

Smith, M., Pollio, H., and Pitts, M. (1981) Metaphor as Intellectual History: Conceptual Categories Underlying Figurative Usage in American English from 1675-1975. *Linguistics, 19,* 911-935.

Sun, R. (1995) A Microfeature Based Approach Towards Metaphor Interpretation. In *Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence, IJCAI-95* (Montreal), 424-429.

Tourangeau, R. and Sternberg R. (1982) Understanding and Appreciating Metaphors. *Cognition, 11,* 203-244.

Turner, M. and Fauconnier, G. (1995) Conceptual Integration and Formal Expression. *Journal of Metaphor and Symbolic Activity, 10(3).*

Tversky, A. (1977) Beyond Similarity. Psychological Review, Vol. 84, No. 4, pp. 327-352.

Veale, T. and Keane, M. (1992) Conceptual Scaffolding: A Spatially-Founded Meaning Representation for Metaphor Comprehension. *Computational Intelligence, 8(3),*494-519.

Veale, T., O'Donoghue, D. and Keane, M. (1995). Epistemological Issues in Metaphor Comprehension: A Comparison of Three Models. Presented at *ICLA'95, the 1995 Cognitive Linguistics Conference* (Albuquerque, NM).

Wilks, Y. (1975) A preferential pattern-seeking semantics for natural language inference. *Artificial Intelligence, 6,* 53-74.

Wilks, Y. (1978) Making preferences more active. *Artificial Intelligence, 11,* 197-223.