Conceptual Scaffolding:

A Spatially-Founded Meaning Representation For Metaphor Comprehension

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Abstract

Once viewed as a rhetorical and superficial language phenomenon, metaphor is now recognized to serve a fundamental role in our conceptual structuring and language comprehension processes. In particular, it is argued that certain experiential metaphors based upon intuitions of spatial relations are inherent in the conceptual organization of our most abstract thoughts. In this paper we present a two stage computational model of metaphor interpretation which employs a spatially-founded semantics to broadly characterise the meaning carried by a metaphor in terms of a *conceptual scaffolding*, an interim meaning structure around which a fuller interpretation is fleshed out over time. We then present a semantics for the construction of conceptual scaffolding which is based upon core metaphors of collocation, containment and orientation. The goal of this scaffolding is to maintain the intended association of ideas even in contexts in which system knowledge is insufficient for a complete interpretation. This two stage system of scaffolding and elaboration also models the common time lapse between initial metaphor comprehension and full metaphor appreciation. Several mechanisms for deriving elaborative inference from scaffolding structures, particularly in cases of novel or creative metaphor, are also presented. While the system developed in this paper has significant practical application, its also demonstrates that core spatial metaphors clearly play a central role in metaphor comprehension.

Keywords: Metaphor Comprehension, Natural language Processing. Conceptual structures, Cognitive Modelling.

1. Introduction

Traditionally, metaphor has been viewed as a superficial, linguistic phenomenon, as the mere rhetorical "icing on the cake" of normal, literal discourse. However, in recent years an alternative view has gained ground, which argues that metaphor and analogy play a crucial role in the acquisition of new conceptual structure (see e.g., Lakoff & Johnson, 1980; Martin, 1990; Way, 1991). From this perspective, language is viewed as fundamentally metaphorical in nature and metaphor is given a central role in the development of conceptual structure. Lakoff & Johnson (1980) have argued that people's conceptual systems are fundamentally structured by *core metaphors*; for example, that abstract concepts like emotions, are metaphorically structured by concrete spatial concepts such as orientation (e.g., happiness is up and sadness is down). This view clashes strongly with the traditional "substitution view" of metaphor, which claims that a metaphor is interpreted by substituting a literal equivalent for the figurative statement (see e.g., Black, 1962).

The aim of our research is to advance on both a theoretical and an applied front. *Theoretically*, our aim is to investigate the notion that core experiential metaphors can be used to interpret figurative language. In particular, we aim to produce one model of this general notion in order to determine its feasibility as a candidate account of metaphor processing. In an *applied* context, our aim is to produce a working system designed to construct conceptual structures in an indexed knowledge-base by processing natural language texts (e.g., computer product reviews; see Cunningham & Veale's, 1991a, 1991b, TWIG system). These texts are permeated by figurative language which has to be interpreted if the system is to work successfully. For example, reviews frequently mention that "computers are infected by viruses", that "laserprinters eat postscript commands" and that "companies do battle in the market place".

The essence of the present work is that metaphors can be interpreted through core spatial metaphors forming a *conceptual scaffolding* between concepts. The role of the conceptual scaffolding is to create associations between ideas. However, these basic associations do not capture all subtleties and nuances of meaning in a metaphor. Rather, these associations form a supportive scaffolding for the further fleshing out of the metaphor's meaning using relevant domain knowledge.

In the remainder of this paper this perspective is elaborated further. In the next section, we outline our general theoretical viewpoint in a little more detail. Then, we show how the idea of conceptual scaffolding can be specified using a spatially-founded semantics based around the core experiential metaphors of collocation, containment and orientation (see section 3). Later, we show how these ideas are instantiated in the context of the TWIG knowledge-base management system through the use of several worked examples (see section 4). The final sections cover the ways in which conceptual scaffolding may be used to elaborate the semantic subtleties of metaphor (section 5) and how it may be extended to deal with issues of coherence (e.g., lexical ambiguity, metonymy, and metaphoric substitution; see section 6) before concluding the paper.

2. Conceptual Scaffolding as a Model of Metaphor Interpretation

According to the view of metaphor developed here, two complementary processes can ensue when figurative language is comprehended. First, at the very least, a metaphor will establish an association between two concepts. It is this association which is captured by the idea of a *conceptual scaffolding* between concepts. Second, the metaphor may establish a rich set of semantic relations between the concepts. We view this elaboration of semantic relations as something which is supported by the conceptual scaffolding.

Many metaphors take time to be fully appreciated, or can be elaborated over time as they are reflected upon and further information is added (e.g., consider the elaboration of the light and dark metaphors in Shakespeare's *Macbeth*). The scaffolding acts as an interim framework during the gradual development of such a conceptual structure. During the elaborative stage of processing a full interpretation of the metaphor is gradually *fleshed out* around the basic conceptual scaffolding.

In effect we advocate a two-stage process of interpretation:

Stage 1: A Scaffolding is constructed to associate the concepts evoked by an utterance in a way which is representative of the broad semantic themes of the utterance.

Stage 2: This basic scaffolding structure is elaborated by various inference mechanisms which factor in matters of general world knowledge, specific domain knowledge and narrative context.

The scaffolding itself stresses the association and disassociation of different ideas, and is constructed from a fixed set of spatially-founded operators, which encode our experiential intuitions about collocation, containment and orientation.

This *fleshing out* / elaboration of a conceptual scaffolding involves the following processes:

- The labelling of an association with a specific conceptual relationship (section 4)
- The inference of new associations to augment the basic scaffolding structure (section 5)
- The establishment of coherence across the conceptual scaffolding (section 6)

Of course, it may arise that not every part of the scaffolding is open to elaboration; this is particularly so when a metaphor is used to remedy a gap in our conceptual repertoire. In these cases the scaffolding maintains the intended association of ideas until such time that additional conceptual relations are acquired to "fill the breech". For example, the conventional metaphor "to catch a cold" expresses an association of concepts (person and virus) that is essential to our understanding of infection, contagion and other concepts. But, even if a listener had no conception of infection the metaphor would, at the very least, yield a minimal interpretation based upon the association of *person* and *virus*. In turn, this association can act as the basis of useful inference (e.g., that the *person* acquires the observable qualities (*symptoms*) of *virus*).

In the following sections we elaborate this theory of figurative language processing. In the next section we show how a spatially-founded semantics based on core metaphors can be used to form conceptual scaffolding. Then in later sections we elaborate the different ways in which metaphoric interpretations can be elaborated based on this conceptual scaffolding.

3. A Spatial Semantics for Conceptual Scaffolding

In the following sub-sections we will elaborate operators to capture the association or disassociation of ideas, and use these as core connectives for the construction of conceptual scaffolding. These operators are based upon the core metaphors of collocation, containment and orientation, employing a semantics based upon natural intuitions drawn from physical experience. We also demonstrate how the orientation metaphor schema can be usefully employed to characterize the functional properties of both simple and structured concepts.

3.1 Connection and Causality Operators in Conceptual Scaffolding

A fundamental role of metaphor is the association or disassociation of different ideas. We can represent the essential nature of idea association and disassociation with the experiential spatial metaphor of collocation. Within this metaphoric schema, idea association connects (or collocates) two concepts such that they are brought together, while idea disassociation disconnects (or dislocates) two concepts such that they are separated and taken apart.

This schema is captured by the equivalent spatial operators CONNECT and DISCONNECT, the use of which is demonstrated in Figure 1.

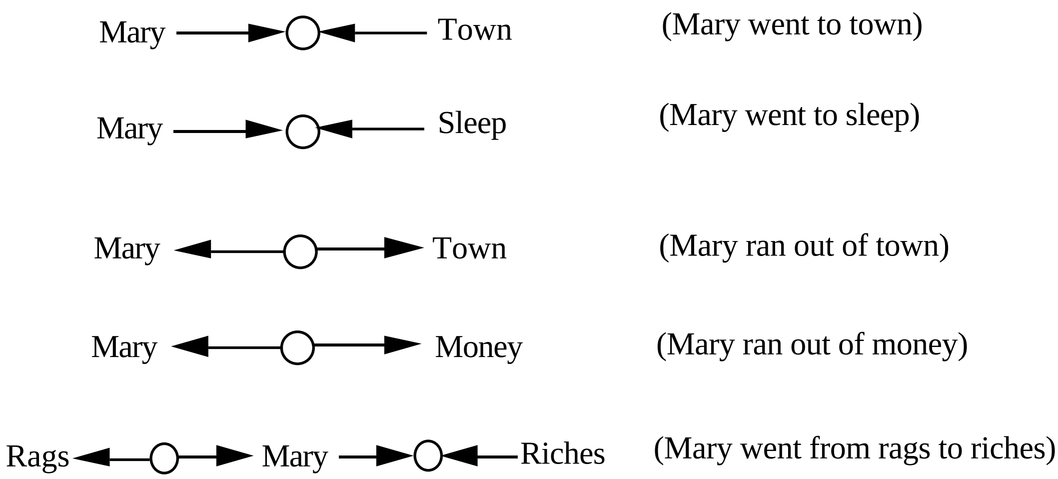


Figure 1: Literal and Metaphoric Uses of Spatial Collocation Captured by the Spatial Operators CONNECT *and* DISCONNECT

The examples of Figure 1 demonstrate that the collocation schema may be employed either metaphorically or physically (where actual spatial collocation is represented) to capture the core meaning in a variety of related sentences.

It should be clear that the collocation operators require a complementary set of causality operators if meaning structures of any complexity are to be represented. To this end, the semantics supports the causality operators ACTUAL-CAUSALITY and ATTEMPTED-CAUSALITY. These basic operators complement the spatial operators (of which there are more to come later) to capture the actual and figurative meanings of a wealth of verbs. For example, these operators provide adequate expressive power to capture the regularities inherent in the different connotations of GIVE (see Figure 2).

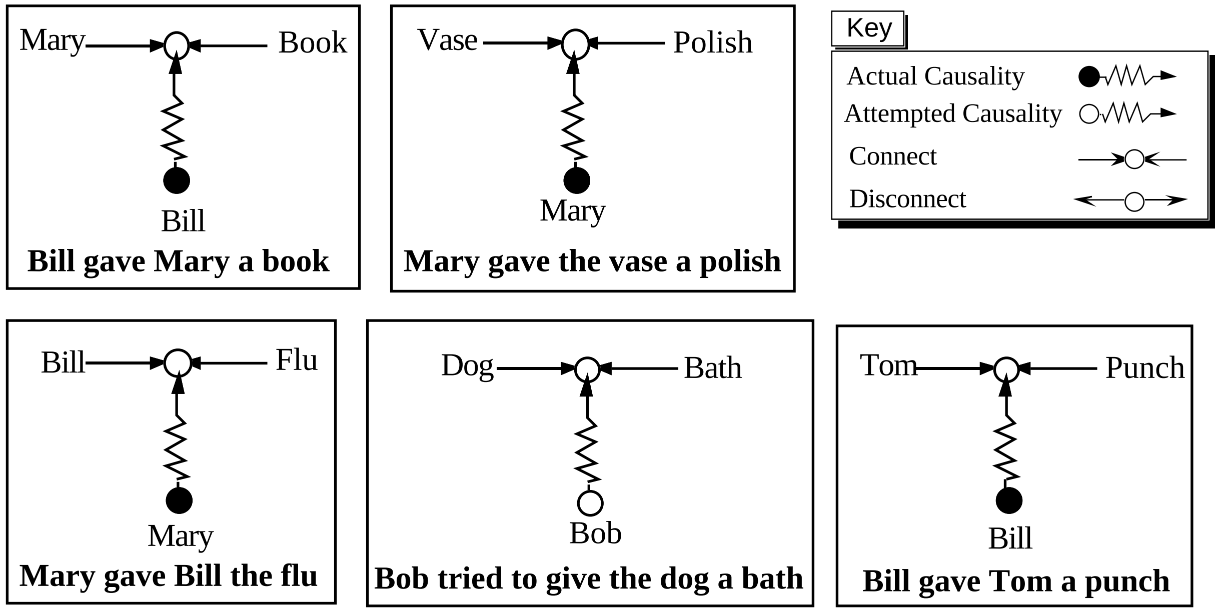


Figure 2: Five Forms of the Verb TO GIVE

Because the spatial operators can represent both metaphoric and physical occurrences of collocation, the same scaffolding structure is created for a diversity of different situations. However, this does not necessarily mean that we lose conceptual information. The elaboration processes which act upon these scaffolding structures take into account the specific concepts involved, and so can reinstate the semantic diversity between different utterances.

We shall not dwell upon the implications of causality representation, for while causality forms a necessary component in any model of meaning representation, it is presented here simply to facilitate discussion of the spatial foundations of the system. For the same reasons we exclude issues of tense and modality from our discussion. Note that throughout this paper, spatial operators will be employed both graphically (as in Figures 1 and 2), and in a written functional form; thus, Figure 2 (top left) is also expressible as actual-cause(Bill, connect(Mary, Book)).

It is also necessary to provide a specialization of collocation that deals with containment, which is another fundamental core metaphor that influences the organization of our conceptual systems (see Lakoff & Johnson, 1980). CONTAIN and RELEASE are, respectively, specializations of CONNECT and DISCONNECT. These containment operators are specializations because (i) they are non-symmetric, each concept must assume either the role of container or containee; and (ii) they facilitate special inference using knowledge of containers and their contents. Some examples of the containment metaphor are shown in Figure 3.

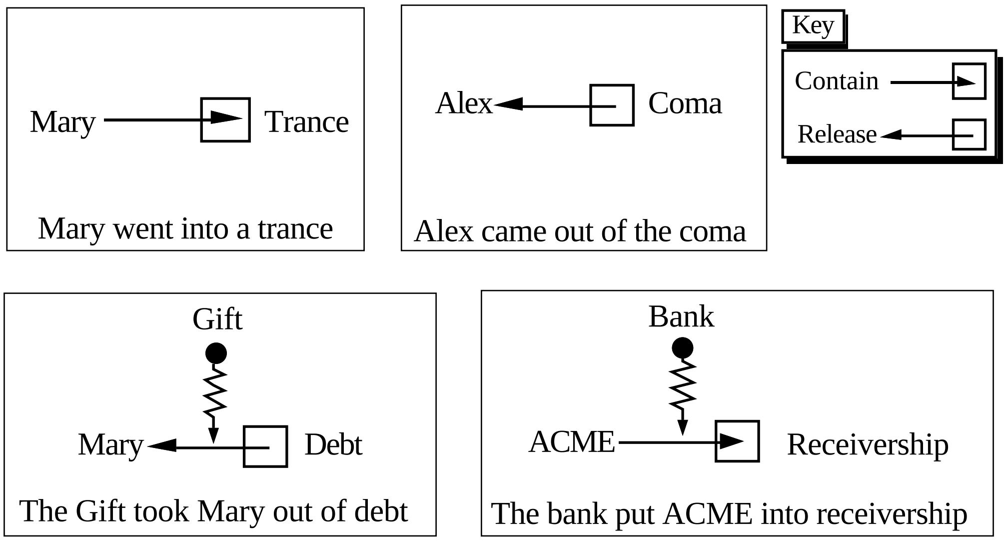


Figure 3: Containment Metaphors and Their Underlying Conceptual Scaffolding

To understand the need for container knowledge, consider the utterance "Bill has fire in his veins". The use of the preposition *in* acts as a containment cue, enabling the system to recognize that the backbone of the metaphor is an association between Fire & Blood rather than Fire & Veins. This inference exploits the system's container knowledge that veins are effectively containers of blood; such knowledge forms part of the definition of container concepts. Once this association between Blood & Fire is created, the metaphor can be recognized as an extension of "Bill is hot-blooded", itself a metaphor.

3.2 The Role of Spatial Orientation in Conceptual Scaffolding

Orientation metaphors are spatially-founded mappings which organize whole systems of concepts in a coherent and systematic manner. While we can conceive of a number of different orientation operators, the most coverage is offered by just two: UP and DOWN.

These spatial operators organize many everyday concepts, as demonstrated in "Share prices *sunk* into oblivion", "The software industry is *buoyant*.", "Apple *dropped* the price of the Macintosh LC", and "Bill *fell* into a depression". These operators are used to characterise the basic meaning of many concepts. As we will see below, they can be applied to both simple and structured concepts in order to characterise important attributes of these concepts.

There exists a family of *neutral concepts*, such as *price, amount, wealth,* and *mood,* to which orientation operators can be applied to characterise the meaning of *directed concepts,* such as *cheap, many, rich,* and *happy*. For instance, UP(Size) represents the meaning of the directed concepts *big* or *large*, where *size* is a neutral concept; Up(Mood) → Happy whereas Down(Mood) → Sad; and Up(Speed) → Fast while Down(Speed) → Slow. The same neutral concept may support many directed concepts, such that Up(Size) → {big, large, ...} and Up(appearance) → {pretty, beautiful, clean, ...}. These orientation operators thus allow us to characterise a wealth of *directed* (or polar) adjectives (antonyms), as demonstrated in Figure 4.

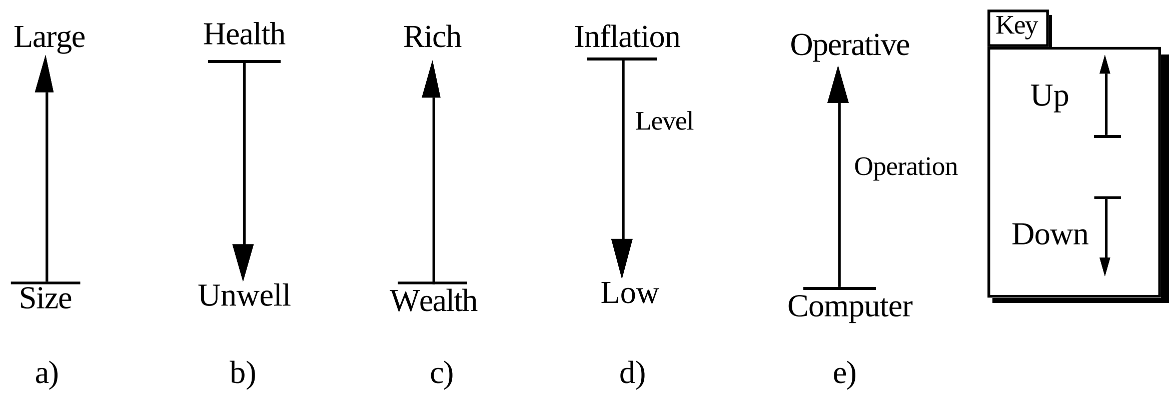


Figure 4: Application of the Spatial Orientation Operators Up & Down

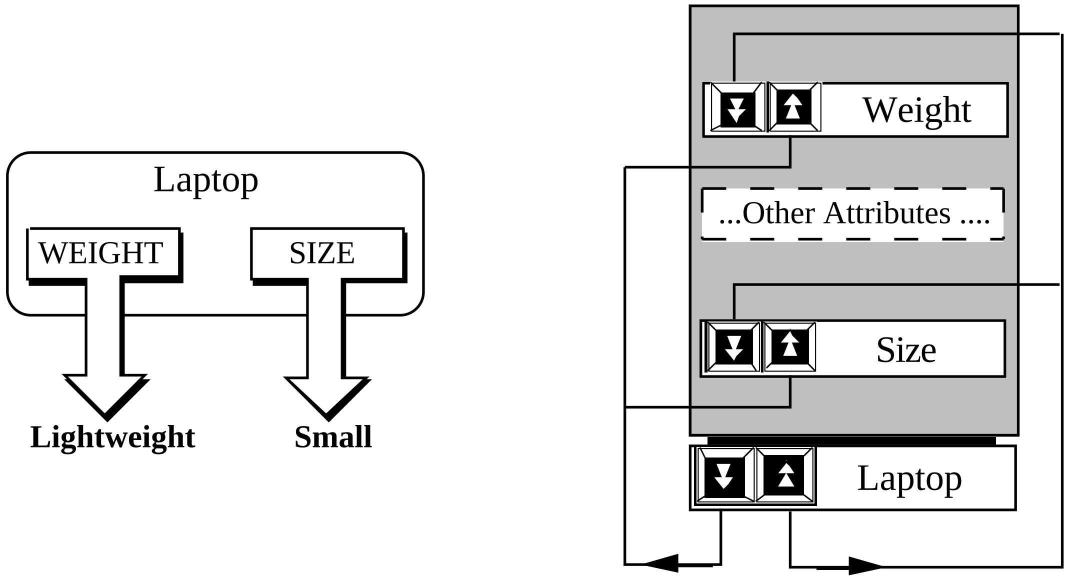
Examples 4a to 4c graphically illustrate the application of an orientation operator to a basic *state* or *dimension* concepts -- *size*, *health* and *wealth* -- to produce the corresponding polar descriptors *large*, *unwell* and *rich*. Examples 4d and 4e demonstrate the application of orientation operators to more complex concepts which have an internal attribute structure. Concepts such as *inflation* and *computer* do not react to orientation as a whole, rather the applied orientation is redirected to a particular set of associated attributes. A dotted notation is used to target a specific attribute of a structured concept; this is represented graphically as a label in Figure 4. Thus, Down(Inflation) → Down(Inflation.level) and Up(Computer) → Up(Computer.Operation).

As presented in this section, the orientation operators Up & Down support the representation of basic positive or negative connotations respectively. For example, applying an upward orientation to a concept such as Mood allows that concept to be considered in a positive context, supporting the inference that Mood → Happy. However, this bipolar representation would certainly seem to lack the finesse needed to capture the degrees of connotation frequently employed in natural language utterances. For instance, while the verbs To Slaughter, To Kill and To Hurt each cause a negative state change, effectively a downward orientation, all three clearly represent different degrees of application. However, we feel that such distinctions are best dealt with in the elaboration stage of processing. Such gradation of effect is a current topic of research in the Conceptual Scaffolding model, and so for purposes of clarity, will not be employed in the examples shown in this paper.

3.2.1 Application of the Orientation Operator to Structured Concepts

As demonstrated above, orientation operators apply directly to basic concepts such as states and dimensions, but most concepts of interest, such as artefacts and natural kinds, will have an internal attribute structure to which the operator is redirected. The target of the operator is largely dependent upon context, such that the operator will select those attributes which are most salient in the current situation.

Regardless of context, an orientation operator will naturally prefer those attributes which contribute to the function of the concept as a whole. We call these attributes the *functional attributes* of a concept (for related ideas, see Keane, 1985, 1988). In the case of artefacts (such as computers) and artificial abstractions (such as inflation), these functional attributes are a matter of design, while in the case of natural kinds, such as fire and food, functional attributes are a matter of usage. For instance, as an economic indicator, level is the only functional attribute of Inflation. As demonstrated in Figure 5, functional attributes will also tend toward specific orientations.



a) Functional attributes of a Laptop **b) Encoding functional properties**

Figure 5: Representing the Functional Properties of a Structured Concept: a) Illustrates That Such Properties have Specific Orientation Tendencies; b) Shows How These Tendencies are Represented Within a Concept.

As illustrated in Figure 5, the functional attributes of the concept *laptop* are *weight* and *size*; these attributes both have downward orientations, such that the better a laptop, the smaller and lighter it should be.

Up(Laptop) $\Rightarrow$ Down(Laptop.Weight) AND Down(Laptop.Size)

Down(Laptop) $\Rightarrow$ Up(Laptop.Size) OR Up(Laptop.Weight)

Naturally, functional attributes are also inherited; for instance, a product such as the ZX-Laptop is an aggregation of functional attributes from the concepts *laptop*, *computer* and *product*. Recognition of this fact allows the system to view the concept from any of three different perspectives, either as a product, a computer or a laptop, as dependent upon the context. In turn, such perspectives allow the system to mask the attributes of a concept to determine which are salient when orientation is applied. For example, consider Figure 6, in which the same orientation operator selects a different attribute of the same concept in different contexts:

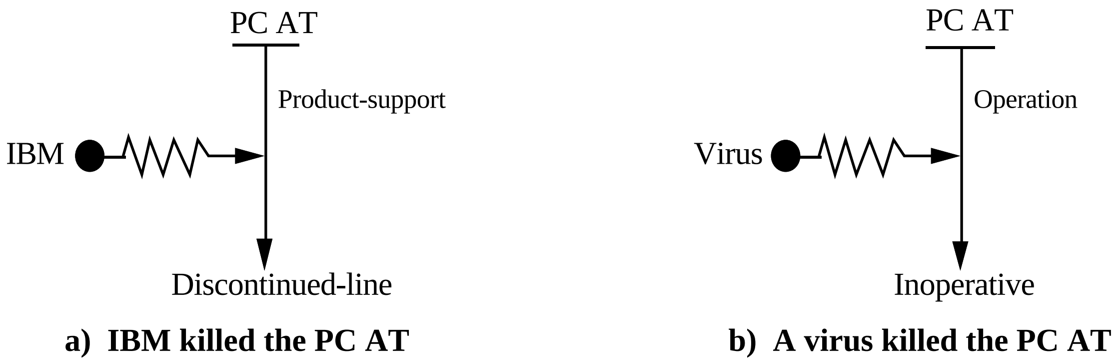


Figure 6: A Different Attribute Of PC-AT Is Targeted By Down(PC-AT) In Each Context.

The situation is resolved by considering how the causal agent interacts with the affected patient in each case. IBM, as a corporate entity, is seen as the manufacturer of the PC-AT product, while a virus is a computational entity which operates on the PC-AT computer. Thus, by taking a wider view of the situation, the PC-AT can be viewed from different perspectives, that of *product* in 6a, and *computer* in 6b. The functional attributes of each perspective are used to interpret the action of the orientation operator in each case.

3.3 Core Scaffolding: Capturing Commonalities Across Verb Meaning

The basic operators for causality, collocation and orientation combine to form compound operators or core scaffoldings that capture the underlying structure of many different actions. For example, the combination of causality and orientation results in the compound structures or basic scaffoldings of Figure 7.

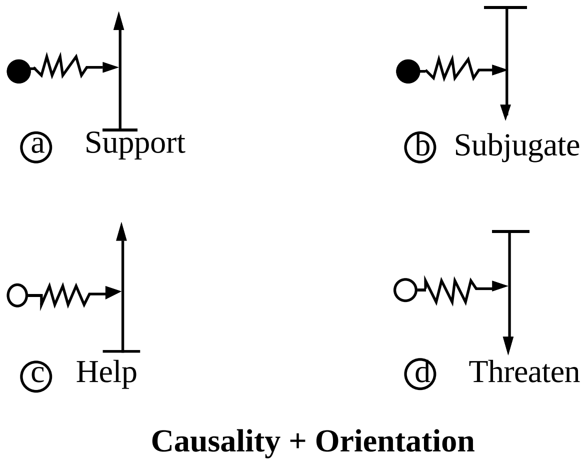


Figure 7: Core Structures Formed From the Causality & Orientation Operators

Likewise, the combination of causality and collocation (connection & disconnection) forms the compound structures of Figure 8.

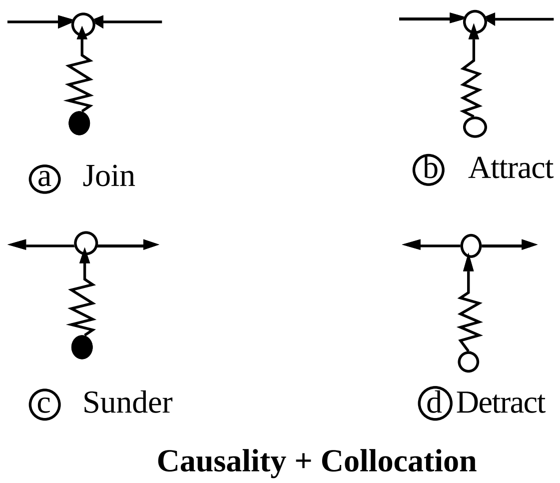
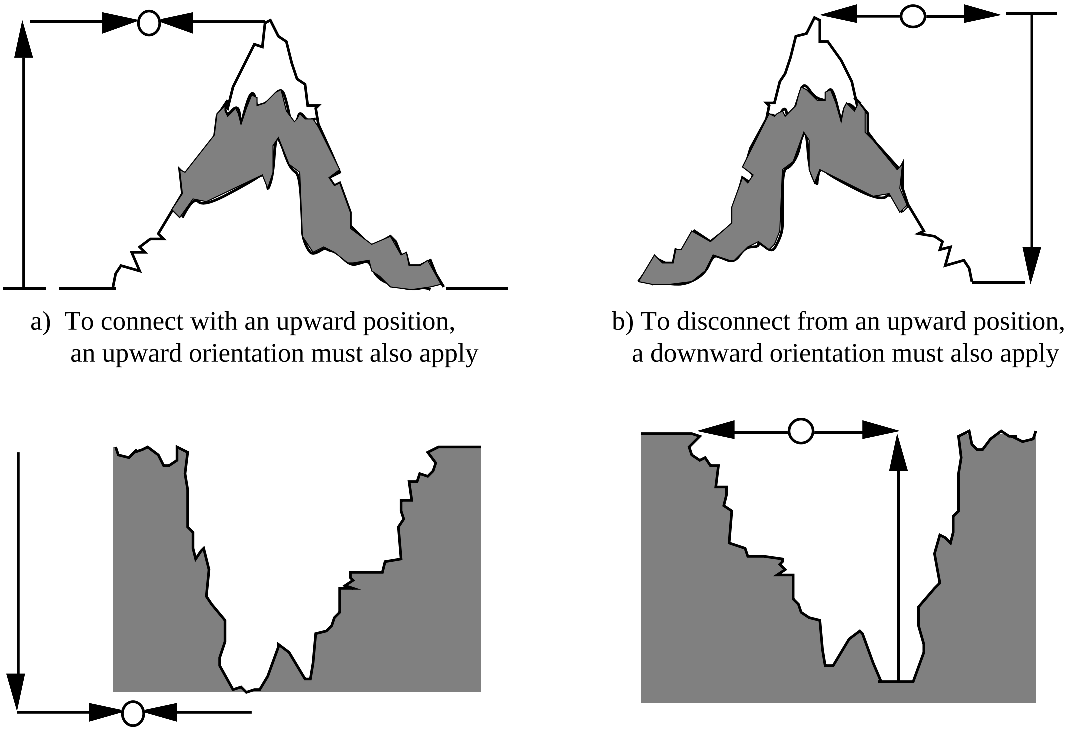


Figure 8: Core Structures Formed From the Causality & Collocation Operators

These compounds have names which are representative of their spatial nature and their roles in specifying the semantics of higher-level verb concepts. Effectively, verbs are represented as operator frameworks which guide the construction of a conceptual scaffolding around which a meaning structure may be built. Note that the Join compound of figure 8a is the scaffolding of the verb *to give*, as illustrated in Figure2. Indeed, many verbs which are considered to be *core-related* -- such as *to give*, *to get*, *to receive* -- are actually related through a similar underlying scaffolding structure (see Martin, 1990 and Wilensky, 1991, for a discussion on the nature of core-related words / concepts).

3.4 Spatial Interactions: Combining Collocation & Orientation

We can metaphorically view mental and physical states as locations which may be reached, occupied and left behind. We talk of finding happiness, searching for enlightenment, catching the flu, going to sleep and so on. Because locations can also be viewed as containers (of buildings etc), states may also be viewed as metaphoric containers. We say "Donald is in trouble", "Ivana entered a depression", and "Marla went into a trance". These states may in turn possess inherent orientations (e.g., the *sleep* state has an inherent downward orientation - *to fall asleep*), such that the semantics of collocation and orientation are intrinsically related. We can draw from actual spatial & physical experience to indicate how the operators of orientation and collocation should interact within a conceptual scaffolding. These intuitions can be summarized as follows: to collocate (connect) with an upward position, one must go *up*; to dislocate (disconnect) from an upward position, one must go *down*; to collocate with a downward position, one must go *down*; and to dislocate from a downward position, one must go *up*. Such spatial intuition is illustrated in Figure 9.



a) To connect with an upward position, an upward orientation must also apply

b) To disconnect from an upward position, a downward orientation must also apply

c) To connect with a downward position, a downward orientation must also apply

d) To disconnect from a downward position, an upward orientation must also apply

Figure 9: Physical Experience Provides Intuitions About How The Operators Of Collocation And Orientation Should Interact.

We formalize these intuitions about orientation and collocation within the spatial semantics by viewing the collocative operators as projecting orientation from one concept onto another.

CONNECTION projects orientation from one concept onto another. When two concepts are connected, and one concept possesses a spatial orientation, then that orientation may be projected onto the other. For example, "The economy went into a depression" is resolved by projecting the orientation DOWN from Depression onto Economy.

Connect(X, Up(Y))	≡	Connect(Up(X), Up(Y))	{figure 9a}
Connect(X, Down(Y))	≡	Connect(Down(X), Down(Y))	{figure 9c}

DISCONNECTION projects opposing orientation from one concept onto another. When two concepts are disconnected and one of those concepts has an inherent spatial orientation, then the opposing orientation may be projected onto the other. For example, "IBM came out of its trance" is resolved by projecting the opposite orientation of trance, UP, onto IBM.

Disconnect(X, Up(Y))	≡	Connect(X, Down(Y))	{figure 9b}
Disconnect(X, Down(Y))	≡	Connect(X, Up(Y))	{figure 9d}

Thus, where orientation is involved, a Disconnection may be resolved in terms of Connection. Such a resolution expresses the opposition between Disconnect & Connection via the opposition between Up & Down. In the next section we shall discuss other strategies by which the Disconnect operator may be so resolved.

This combination of collocation and orientation operators allows for some powerful metaphoric inference. For example, connect(Computer, Healthy) $\Rightarrow$ Up(Computer) as Up(Health) $\rightarrow$ Healthy. Likewise, connect(Product, Platinum) $\Rightarrow$ Up(Product) as platinum has a positive connotation, represented as an upward orientation. As a worked example, consider the metaphor "OS/2 lost a fortune", which is resolved as follows:

Disconnect(OS/2, Fortune)	≡	Disconnect(OS/2, Up(Wealth))
	≡	Connect(OS/2, Down(Wealth))
	$\Rightarrow$	Down(OS/2)
	$\Rightarrow$	Down(OS/2.Market-share)

The attribute Market-Share is targeted as it is most salient (primed) in the context of Wealth.

4. Instantiating Conceptual Scaffolding within a Knowledge Base

Having outlined and discussed the construction of a conceptual scaffolding which is representative of the broad meaning of an utterance, let us now focus on how this scaffolding is *instantiated* in the system knowledge base. In particular, let us look at the representational requirements of the model from the perspective of a knowledge-base management system (KBMS). The instantiation of a scaffolding structure requires that a specific conceptual relation be determined for each association, and as such, the process can be viewed as part of the elaborative stage of comprehension. This section concludes with an analysis of some of the sample metaphors that the TWIG system has encountered.

4.1 Knowledge-Based Labelling of Concept Associations

Once a scaffolding structure has been constructed which captures the associations representative of an utterance's meaning, this structure is instantiated within the system knowledge base. Effectively, the associations comprising the structure are labelled with relations derived from the interaction of the associated concepts. In terms of a frame-based KBMS (see Lenat & Guha 1990), labelled associations translate directly into frame relational links, essentially triples of the form Frame.Slot.Value (F.S.V), where F and V correspond to the associated concepts and S corresponds to the association label. Examples of such triples are Banana.Colour.Yellow (Bananas are yellow) and Porsche.Speed.Fast (Porsches are fast). However, association at its most general is a symmetric notion, whereas frame relations are inherently directed: F.S.V is only equal to V.S.F in the special case of F = V. The power of conceptual scaffolding lies in the determination of association labels (and thus, direction, in the frame sense) *after* the associations have been made. These patterns of association, in effect networks of spatial operators, are general enough to capture the broad strokes of literal and metaphoric meaning alike, while the labelling of associations assigns a specific meaning to the network in terms of the concepts involved. The labelling process thus amounts to finding a plausible frame triple for each association.

The KBMS is probably best viewed as a knowledge *server*, whose intake is a concept association (simply a concept pair), and whose output is a concept relation (frame triple). Requests to the server are made in the form of the spatial operator Connect, as directed by the higher level language interpretation processes (such as syntax analysis and the application of verb semantics). Connect is the basic idea association operator; the following section will illustrate how the disconnect operator is instantiated under this scheme). A KBMS reply, when non-empty, may assume either of two different imperative forms, CONNECT and SUBSUME; subsumption indicates a taxonomic relationship between concepts, while connection indicates an attributive relationship. The use of such a server is illustrated in Figure 10.

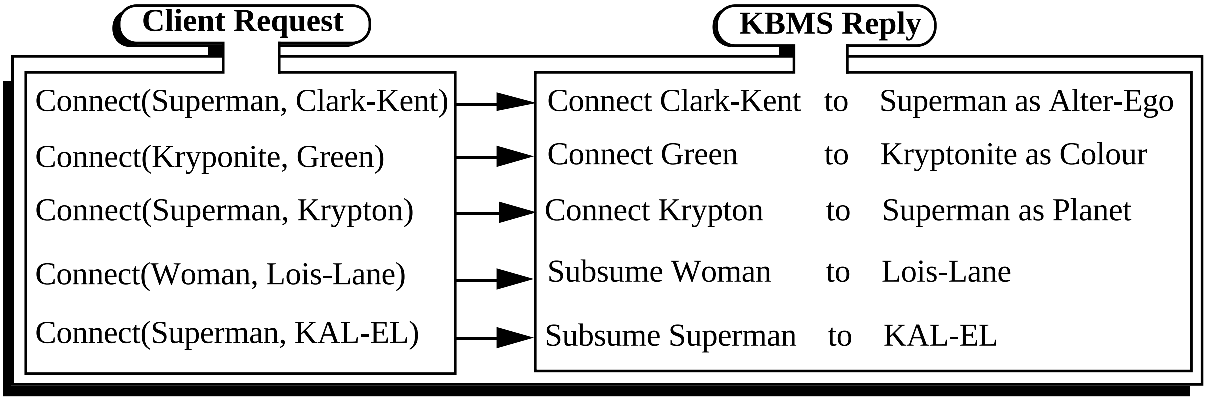


Figure 10: The Knowledge Server in Action

The appropriate KBMS reply is dependant upon the nature of the concepts involved, as follows:

A *Subsumption* relation exists between two concepts X and Y if X is a superclass of Y or Y is a superclass of X.

A plausible *Connection* Z exists between two concepts X and Y if X has an attribute Z which is a superclass of Y, or Y has an attribute Z which is a superclass of X.

The KBMS will not always formulate a frame triple for every association; such is the nature of metaphor, and indeed, the nature of conceptual scaffolding. However, each unlabelled association is maintained by the KBMS until such time that there is sufficient knowledge to label it. Whenever the frame structure of a concept is modified, the unlabelled associations of that concept and its specializations are then re-evaluated.

4.2 Opposition and Negation in Conceptual Scaffolding

In this section we present some knowledge-based rules for the determination of conceptual opposites. The world is full of natural opposites; for example, Friend & Foe, Dead & Alive, and Fast & Slow. To supplement the coverage of natural opposites, artificial opposites may also be created, such as Green & Not-Green and Money & No-Money. Such a model of conceptual opposition can, in turn, augment the conceptual scaffolding of an utterance to provide a workable representation of negated statements.

The Up/Down orientation schema can be exploited to infer a whole range of natural *directed* opposites:

Opposite(Up(X)) → Down(X)   and   Opposite(Down(X)) → Up(X)

Examples: Opposite(Rich) → Poor and Opposite(Unwell) → Healthy.

There also exists a system of relational opposites such as Ally & Enemy and Partner & Rival, which need to be represented (rather than inferred) directly by the KBMS.

Opposite(X.Opposite) → X,

Examples: Opposite(Friend) → Foe and Opposite(Victim) → Culprit

A model of opposition will also need to create artificial opposites as the need arises:

Opposite(Make-Artificial-Opposite(X)) → X

Examples: Opposite(Greek) → Not-Greek and Opposite(Plastic) → Not-Plastic

The spatial operators CONNECT and DISCONNECT also form a natural opposition, for a movement together is the opposite of a movement apart. In section 3.4 we saw that in certain situations, where orientation is involved, a disconnection is resolvable in terms of connection. This is achieved by expressing the natural opposition between Connect & Disconnect via the corresponding opposition between Up & Down. Having developed a fuller model of conceptual opposition, this can now be seen as simply a special case of a more general phenomenon. DISCONNECTION is therefore expressible as the combination of CONNECTION and OPPOSITION, as captured by the following rule:

$$\text{Disconnect}(X, \text{Opposite}(Y)) \Rightarrow \text{Connect}(X, Y)$$

To see this at work, consider Figure 11. We see that DISCONNECT is treated as CONNECT for the purposes of obtaining a plausible frame connection from the KBMS; this frame connection is then inverted to represent the effects of disconnection. In 11a, the slot concept *partner* is inverted as Opposite(Partner) → Rival. In 11b, the slot concept *mood* has no inverse, so the system inverts the filler concept *happy* to unhappy instead. If neither slot concept or filler concept has a known opposite, an artificial opposite for the filler concept is created. For example, the sentence "The balloon is not red" is handled as Disconnect(Balloon, Red) ⇒ Connect(Balloon, Opposite (Red)) ⇒ Connect(Balloon, Not-Red), where Make-Artificial-Opposite(Red) → red.

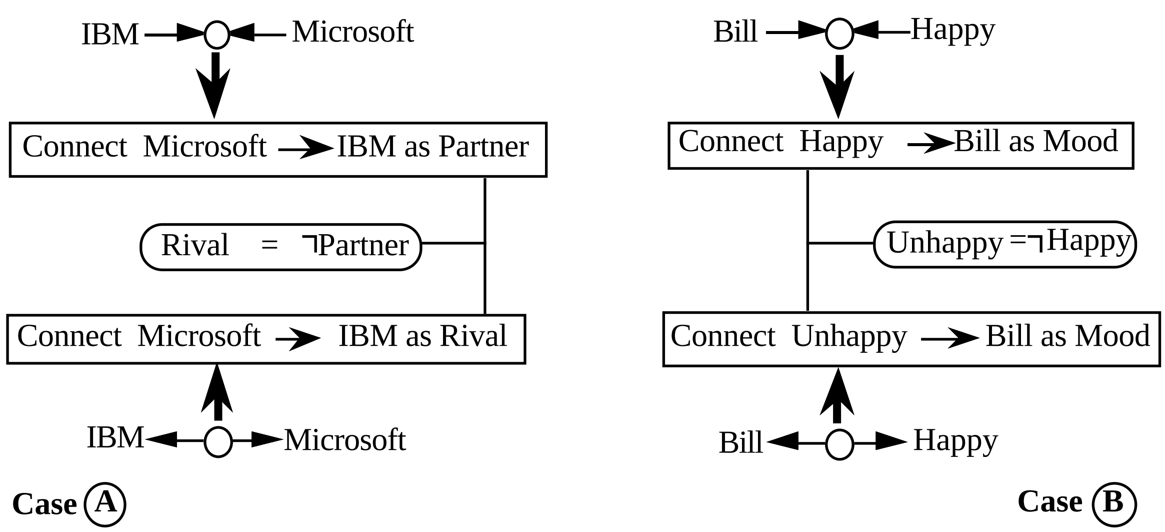
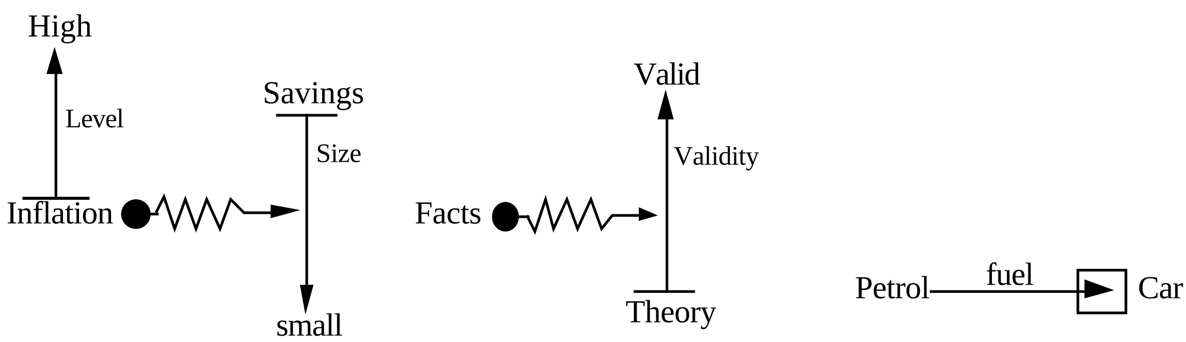


Figure 11: Disconnection = Connection + Opposition

This particular example also highlights the negation of verbs; the semantics of TO BE, a simple CONNECTION, becomes a DISCONNECTION under the influence of NOT. In general, when negation is applied to a particular scaffolding structure, connections become disconnections and vice versa. However, only when the scaffolding is instantiated in the knowledge base need the notion of conceptual opposition be applied. This schema provides an elegant method of obtaining a *workable* representation of negated phrases at the scaffolding level of meaning. Such representation, however, is by necessity *painted in broad-strokes*, allowing negation to swing the meaning of an utterance sharply from one extreme to another. For this reason, the application of negation at the scaffolding level needs to be tempered with additional contextual and domain knowledge at the elaboration stage of processing.

4.3 Some Examples

Having examined various aspects of the conceptual scaffolding model, let us now consider some worked examples of the model in action. Note that in the illustrations that follow, spatial operators are explicitly labelled with actual KBMS frame relations as appropriate. To begin, consider the classic examples of Figure 12 and their conceptual scaffoldings.



a) Strong inflation is withering my savings **b) Facts bolster a theory** **c) Cars drink Petrol**

Figure 12: Classic metaphors

Example 12a illustrates the *spatial framework* of the verb *to Wither*; in this case, Savings are pushed downward by a dominant inflation, personified as an agent. Inflation itself is driven upward, an inference drawn from "Strong inflation", where Up(Strength) $\rightarrow$ Strong and Up(Level) $\rightarrow$ High. Likewise, example 12b demonstrates an occurrence of the prevalent *Support* compound (figure 7a), which is the function of a bolster or buttress. In this case, validity is an important functional attribute of theory, where Up(Validity) $\rightarrow$ Valid. Example 12c is the now classic Wilks metaphor, where the action To Drink is structured around the containment metaphor. In this case, the KBMS determines that vehicles and petrol relate via the Fuel relation.

More complex examples of the model are also presented in Figure 13.

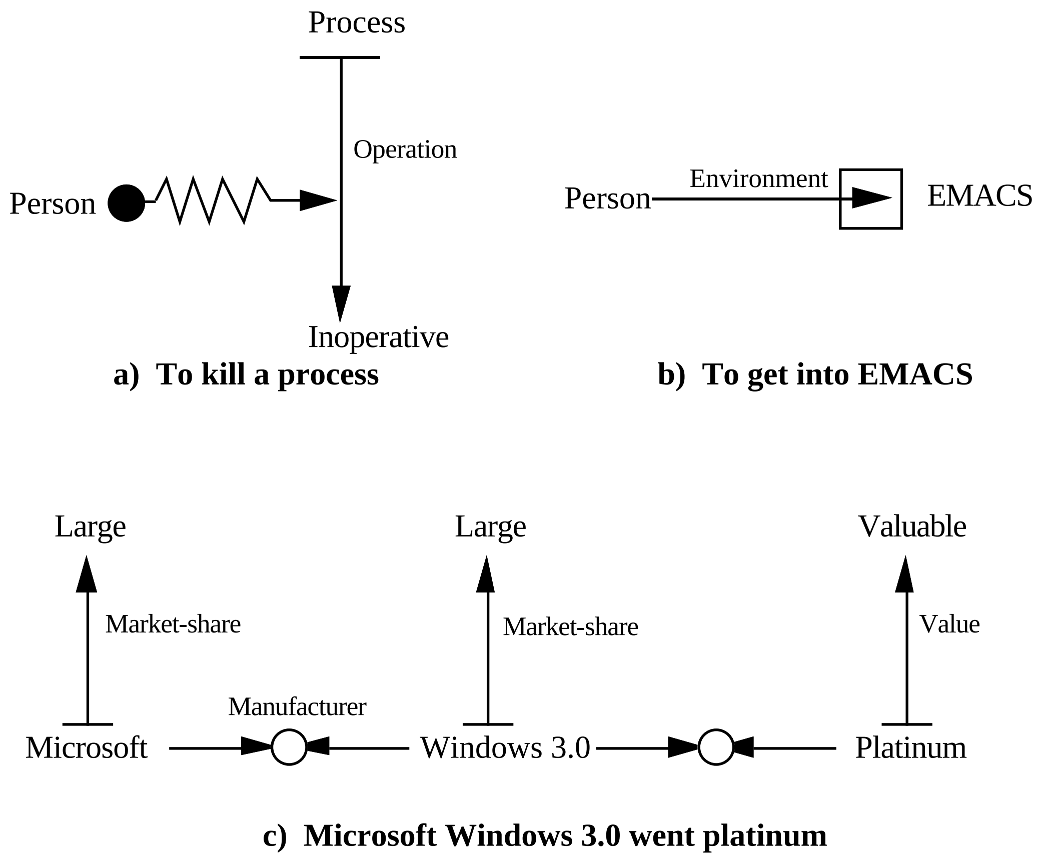


Figure 13: Some Prevalent Computer Metaphors

In Example 13a we see a prevalent metaphor from the computer domain, that of viewing processes as living things. If we imagine the semantics of kill to be defined around the scaffolding actual-cause($culprit, connect($victim, Dead)), where Down(Life) $\rightarrow$ Dead, then the metaphor is resolved using actual-cause(Person, Down(Process)) and Down(Operation) $\rightarrow$ Inoperative, where Operation is a functional attribute of Process. Example 13b is another simple but pervasive computer metaphor, which views active programs as spatial enclosures or environments (see Martin 1990); this is resolved entirely by the KBMS relational server, which determines that People and Interactive Programs (i.e., those programs which place the user in a particular enclosure, such as shells and editors, as opposed to non-interactive and background processes) relate via the Environment relation. Example 13c demonstrates orientation projection, whereby the valuable status (UP) of Platinum is projected onto Windows-3.0, which is in turn mapped onto its manufacturer, Microsoft[1]. Note that a KBMS relation cannot be determined for the association between Windows-3.0 and Platinum; however, the scaffolding structure maintains the association which does at least facilitate the projection of positive connotation.

Many verbs have an implicit (though sometimes well hidden) spatial nature which is readily captured by the spatial semantics of conceptual scaffolding. Consider Example 14, where the opposition inherent in the meaning of the verbs *To Marry* and *To Divorce* is represented via the natural opposition of the Connect & Disconnect operators.The intuitions motivating this representation are clear - *To Marry* is to bring together (usually applied to people, but other uses are common, such as "She's married to her job") while *To Divorce* is to sunder and take apart (again, usually applied to people but other uses abound, such as "He's completely divorced from his emotions.").

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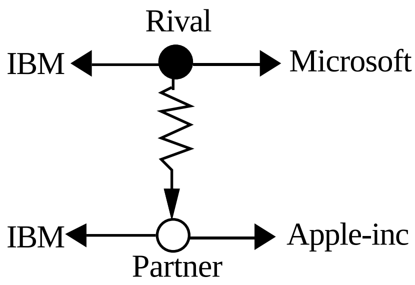
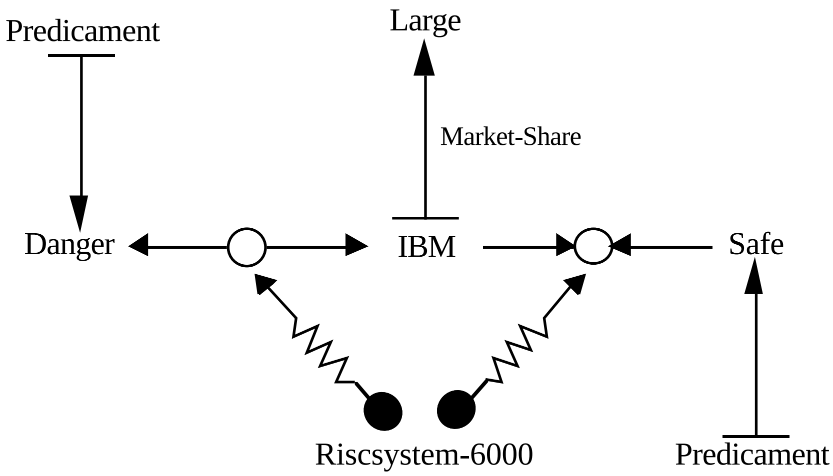
1 Of course, the meaning of *To Go Platinum* has the exact meaning of selling one million copies or more of a particular product. However, without such a priori knowledge, this mapping is totally arbitrary and thus beyond the grasp of any metaphor interpretation system. The best any system can do is exploit metaphor systematicity and project the positive connotation of platinum onto the product in question.



IBM divorced Microsoft to Marry Apple

Figure 14: Connection and Disconnection as inherent in the meaning of Marry and Divorce



The Riscsystem 6000 workstation rescued IBM

Figure 15: By Viewing Abstract state changes as Movement between Physical Locations, The Spatial Semantics can be applied to the most abstract of verbs in the most metaphoric of situations

The basic intuition that abstract states can be viewed as physical locations, and that changes to those states can be viewed as movement between the equivalent locations, provides a solid basis for the semantic definition of even the most abstract of concepts. For instance, we can spatially define the semantics of *To Rescue* in terms of a causal agent which moves the affected patient from a state of *danger* to a state of *safety*. This situation is illustrated in Example 15. Resolution of this metaphor employs Up(Predicament) $\rightarrow$ Safe, connect(IBM, Safe) $\Rightarrow$ connect(IBM, Up(Predicament)) $\Rightarrow$ Up(IBM). As the affected patient, IBM relates to the causal agent Riscsystem-6000 in the capacity of a Manufacturer to a Product (and vice versa); thus, IBM is viewed from a Manufacturer perspective and Up(IBM) is resolved as Up(IBM.Market-Share).

The examples presented in this section highlight not only the construction of conceptual scaffolding, but also some initial stages of elaboration, such as the labelling of inter-concept associations and the interpretation of orientation as applied to structured concepts. In the next section we examine some further mechanisms for such elaborative inference.

5. Elaborative Inference from Conceptual Scaffolding

Having constructed a preliminary scaffolding for an utterance, elaborative inference is performed to flesh out a fuller interpretation around this structure. This elaborative process corresponds to the second tier of our language comprehension model. In section 4 we saw the first step of this process - instantiating scaffolding associations as specific conceptual relations within the knowledge base. The instantiation of an association is elaborative in that it labels the association with a particular inter-concept relation, such as Colour for connect(Porsche, Black) and Manufacturer for connect(Macintosh, Apple-inc). However, where a metaphor is used to remedy a gap in our conceptual repertoire, as in the usage of "to *have* the flu" before the concept of infection has been acquired, such labelling cannot be performed. In this section we present two additional mechanisms for elaborative inference; each mechanism can derive inferences even from associations which cannot yet be labelled. Such coverage is achieved by viewing the associations that make up a scaffolding as possible conduits for attribute transfer.

5.1 Functional Attribute Transfer

As outlined above, the association between two concepts may be usefully viewed as a conduit or channel for *attribute transfer* between concepts. The functional properties of many different concepts can be elucidated using this transfer conduit metaphor. For example, a functional property of Fire is to transfer Heat, while the transference of Colour is a functional attribute of Paint. A natural inference from "Bill painted the house. He used yellow paint." is that the house is now yellow; this inference arises from the association between Paint & House. For metaphors, functional properties can be exploited to make inferential links not only within a metaphor but *between* related metaphors. For example, the metaphor "Bill has fire in his veins" is recognized as an extension of "Bill is hot-blooded" (itself a metaphor) because heat transfer is a functional property of fire. Functional attribute transfer also allows us to model concepts such as Colds and Viruses, where symptoms are used as attributive knowledge which is transferred to the infected Person. As such, knowledge transfer is a mechanism for inferring *new* associations (e.g., as between Person & Symptoms in the Infection-as-possession metaphor).

A transfer is defined in terms of both the attribute involved and the nature of the target concept. Let us define a transfer relation in the following format Transfer(<source> → <attribute> to <target>), indicating a transfer of the feature value <attribute>, from a concept <source> to a concept <target>. Such transfer conditions are stored in the knowledge base and applied whenever a matching association is created as part of a conceptual scaffolding. For instance, Transfer(Fire → Heat) is general enough to allow Heat transfer from the concept Fire across any association to any target concept, while Transfer(Poison → Pain to Animal) will only transfer Pain to those concepts which hold Animal as a superordinate. Likewise, we specify that Kryptonite only effects natives of Krypton with Transfer(Kryptonite → Weak to Kryptonian). At this point, let us consider some worked examples, as illustrated in Figure 16.

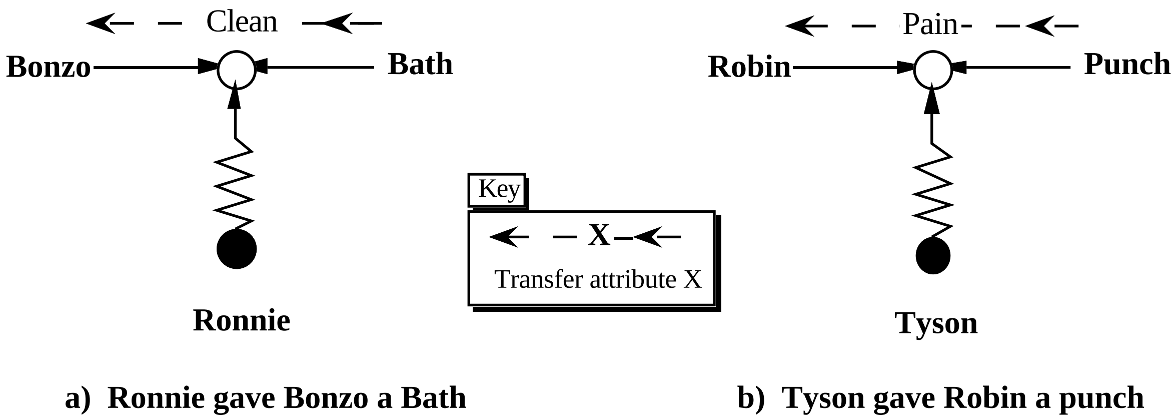


Figure 16: functional attribute transfer across concept associations

Example 16a illustrates Transfer(Bath → Clean), which provides the inference that Bonzo is now Clean. Because an attribute transfer can be viewed as causing a state change in the target concept, the system also infers that Bonzo was not clean before the transfer, rather opposite(Clean) → Dirty. Associations created via attribute transfer are subject to the same causal enclosure as the association across which the attributes are transferred. Thus actual-cause(Ronnie, connect(Bonzo, Bath)) produces actual-cause(Ronnie, connect(Bonzo, Clean)). Example 16b is similarly resolved, employing Transfer(Punch → Pain) to infer actual-cause(Tyson, connect(Robin, Pain)).

If the intended target of a transfer does not match the *actual* target, the transfer is instead viewed metaphorically. For example, "The PS/2 poisoned the PC market." creates an association between Poison and Market, which in turn causes a transfer of Pain, resulting in Down(PC.market) as Down(Physical-Stimulus) → Pain. This also allows the target of the transfer to be viewed metaphorically and the corresponding association to be made, as in this instance, Market = Animal. Consider another example, Transfer(Cure → Healthy to Disease), where it is in the nature of a Cure to bring Health. Now when the system analyzes the utterance "A cure for racism is needed", the concept Racism is viewed metaphorically as (and associated with) the concept Disease.

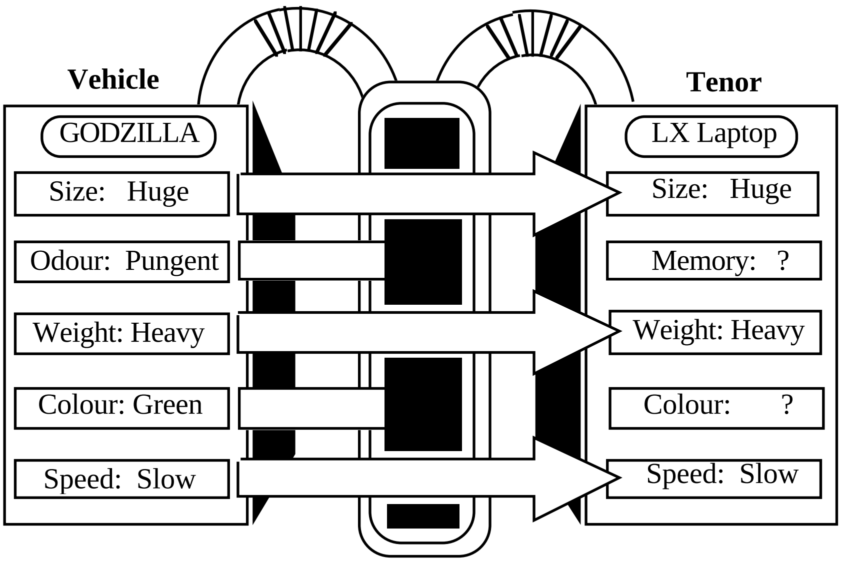
Functional attribute transfer can also support other types of inference, such as inferences about part-whole inheritance. If we are told that "The door of this car is green", the system can use Transfer(Vehicle-Door $\rightarrow$ Vehicle-Door.Colour to Vehicle) to cause this colour information to be transferred across the partonomic association from Door to Car. Attribute transfer can also model the effects of processes; for example, life transfer (alive) and death transfer (dead) are functional properties of the processes Birth and Death respectively.

5.2 Attribute Transfer for Comparative Metaphor

The Association-as-conduit analogy discussed above is employed as a metaphoric schema to elucidate the functional properties of different concepts, such as Birth and Death. We now describe a variant of this scheme called Comparative Attribute Transfer, which occurs whenever a scaffolding association is representative of a comparison between two concepts. For example, the statement "The ZX workstation is a rocket" is a comparative metaphor used to highlight the tremendous speed of the ZX. The association between ZX and Rocket thus acts as a conduit for attribute transfer, where only those attributes of Rocket (denoted as the *vehicle* of the metaphor) which are salient to the comparison are transferred to ZX (the *tenor* of the metaphor).

If we assume the problem to be as clear cut as the mapping of one composite concept structure onto another, the problem is reduced to that of salient attribute determination i.e., which features are to be transferred from the vehicle to the tenor. In this respect, the Spatial Semantics may provide some useful answers. Those attributes chosen for transfer will have to be exemplary in some sense. For instance, when comparing a workstation to a Ferrari, we naturally assume the workstation is very fast (and equally expensive), but not Red and Italian. By the same token, should we compare the new Toshiba LX laptop Macintosh to Godzilla, for instance, the intention of the metaphor is to highlight the excessive weight of the machine (crucial to a laptop's success) and not its green colour or Japanese origins.

Let's assume that every exemplary concept is directed, that is, a concept with an inherent orientation which marks it as extreme relative to a particular dimension. Thus colours and other neutral concepts will not be considered for transfer[2]. We define the exemplary qualities of a concept X relative to a concept Y as those directed attributes of X which also serve as functional attributes of Y. In this respect the direction of the comparison is important to the interpretation. Let us say the Godzilla concept possesses the directed attributes Huge, Slow, Strong, Heavy and Pungent; since Laptop specifies Weight, Speed and Size as functional properties, it is these dimensions which are highlighted by the Laptop = Godzilla metaphor. This masking process is illustrated in Figure 17.



The LX laptop is a real Godzilla

Figure 17: A Comparative Metaphor creates a Transfer Mask using the directed attributes of the vehicle and the Functional Attributes of the tenor.

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[2] Of course, this is one of many heuristic selection measures we can specify to ensure that the most interesting mapping is obtained. Another such selection criterion is Gentner's Systematicity measure (see Gentner 1983), which prefers mappings of higher connectivity.

Other strategies of attribute selection also present themselves. For instance, Way (1991) considers the ontological structure of concepts to be of primary importance in metaphor interpretation. A common superordinate is found between vehicle and tenor, which is then used to mask the concept hierarchy and filter those attributes which are salient to the comparison. Way considers the example "Nixon is the submarine of world leaders", in which Nixon and Submarine share the superordinate Things-which-behave-in-a-secret-or-hidden-manner. Besides expressing an extraordinarily optimistic opinion of (and thus making extraordinary demands upon) the average concept hierarchy, this supertype sheds no light on the metaphor unless its meaning is in someway expressed via its internal (feature value) structure. A taxonomy will provide a concept with an extension but *not* an intension. Consider the example "Bill is a stone"; in this comparison, a common superordinate Physical-Entity is located, but of what use is it? Certainly, common supertypes narrow the selection, but interesting comparison can only be done by structure mapping. In this example, the concept Physical-Entity does not give the system very much to work with.

The strategy of common attribute selection, tempered by the functional attributes of the tenor (as in Figure 17), is a more promising approach. If the content of a concept's name is expressed within its internal structure (e.g., all subordinates of Big-Thing are explicitly *BIG*) then the strategy is equivalent to that of common supertype selection. Additionally, the salient attributes in a comparison are not always those which are held in common, rather those held only by the tenor. For instance, to describe Bill as a stone is to deny to Bill those attributes which differentiate him from a stone, such as the possession of emotions and intelligence. Of course, it would be naive to assume that adequate comprehension is possible without consideration of the context in which the utterance is made. For example, the sentences "Mary is intelligent but Bill is a stone" and "Mary is emotional but Bill is a stone" illustrate how context impinges on the interpretation of a metaphor; the first sentence highlights Bill's poor intellect and the second his lack of emotion. It would be a very helpful concept hierarchy that explicitly tagged the concept Stone as both unintelligent and emotionless; no, if every metaphor is not to be analytic in meaning, such perspectives will have to derived from the metaphors themselves. This of course is the interaction view of metaphor at work (see Black, 1962), for by using Stone to highlight the unintelligent, emotionless nature of Bill, the concept Stone is also illuminated.

6. Establishing Coherence across Conceptual Scaffolding

Thusfar we have concentrated on the creation of scaffolding structures between concepts, with the emphasis on the determination of relational associations, but with little said about the nature of the concepts linked by these structures. However, the many problems of NLU conspire to ensure that such structures are rarely specified in terms of atomic, singular concepts; the nature of language ambiguity, on lexical, structural and referential levels, means that we build conceptual scaffolding not from absolute grounded concepts, but from clusters of alternate concepts. Instead, we should speak of associations between concept *clouds*, as every word employed in an utterance may have multiple readings when viewed at the scaffolding level; there exists a possibility that any reading in a *cloud* is the intended one, but the determination of which reading exactly can only be done by looking at how the cloud interacts with others. Take for example the problem of lexical ambiguity: a scaffolding association between the word concepts Sun and Apple is actually an association between the concept clouds sun<Sun-Star, Sun-inc> and apple<Apple-Fruit, Apple-inc>. The reference of a cloud may be resolved if a plausible KBMS relation is found linking one concept from the cloud to a concept in another. In this example, the KBMS determines a relation Partner linking both Apple-inc and Sun-inc. This situation is illustrated in Figure 18. Note that as a solution to lexical ambiguity, this approach is strictly *localist* in nature; to handle ambiguity which is not resolved using associations in this manner, contextual priming as provided by marker passing (see Charniak 1983) may be required.

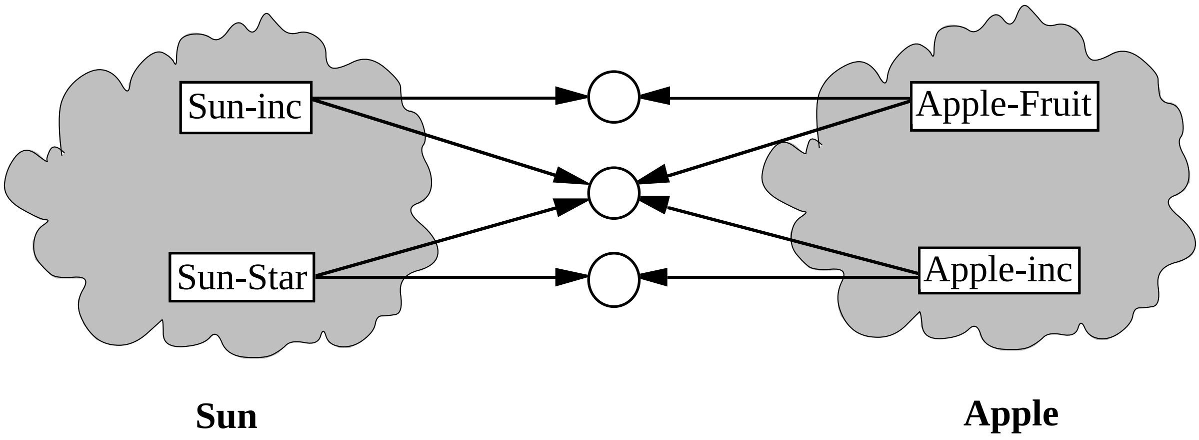

Figure 18: A connection between the concepts Sun and Apple is resolved in terms of the concept clouds {Sun-inc, Sun-Star} and {Apple-Fruit, Apple-inc}.

Language effects other than lexical ambiguity also contribute to the creation of concept clouds: Metonymy, where one concept is used as a proxy for another which is conceptually related (such as using "ham sandwich" to refer to the customer who ordered it); Anaphora, whereby a pronoun or vague reference is used to refer to one of several candidates in context (such as using "it" or "the wrench" to refer to either of "small wrench", "blue wrench" or "rusty wrench"); Domain influence, where the domain of the participant concepts contributes to the interpretation of those concepts; and good old-fashioned metaphoric substitution, whereby one concept becomes metaphorically equivalent to another (such as "red" → angry, "hot" → passionate, "cold" → emotionless, etc). Conceptual scaffolding has nothing novel to offer anaphoric resolution; however, in this section we will briefly present a treatment of metonymy, metaphoric substitution and domain influence which is consistent with the scaffolding model as a whole.

6.1 Metonymy

Metonymy is a language effect whereby a term is used non-literally to refer to a conceptually related term, as in "George Bush bombed Baghdad"; clearly, Bush is used as an oblique reference to the United States Army, and is not intended as the direct agent of the action. Conceptual scaffolding offers a coherent account of such metonymy, within the scope of the spatial semantics.

The operators CONNECT and DISCONNECT facilitate metonymic inference by employing *defaults* imposed by the semantics of the verb. This notion is similar to the preference semantics (Wilks, 1975; Wilks & Fass, 1985), whereby semantic preferences or *loose constraints* are employed within verbs to select the best interpretation of an utterance. We see metonymy as arising at the juncture of semantic preference and actual reference. Effectively, metonymy exploits the existence of a shared set of semantic preferences between speaker and listener to overload the verb of an utterance, and we believe this effect can be adequately modelled by the spatial collocation operators. Rather than enforce a genus-species inclusion constraint on these preferences as commonly used in preference semantics, the more general KBMS *request* Connect(Actual, Default) is used. Such requests can return both subsumptive and attributive relations and metonymy makes use of the latter. To see this at work, consider the following examples:

Resolve: Mary read Tolkien

KBMS Request: Connect(Tolkien, Text-Material)

KBMS Reply: (Connect Tolkien to Text-Material as Author)

Result: Mary read a book whose author was Tolkien

Resolve: Tom drank the bottle

KBMS Request: Connect(Bottle, Beverage)

KBMS Reply: (Connect Beverage to Bottle as Content)

Result: Tom drank the beverage which was the content of the Bottle

Many of the explicit metonymic inference rules of the form discussed by Fass (1991), such as Producer for Product and Controller for Controlled, are thus implicit within the relational structure of the KBMS. In each case, such relational knowledge is used to resolve the oblique reference and augment the final interpretation. In neither case, though, does the system *look for* and *react to* metonymy, as is the case with most treatments of the problem (for example, see Barnett et al 1990); rather the correct reference emerges from the use of conceptual scaffolding and the spatial semantics. It should be noted, however, that this approach is not put forward as a complete treatment of metonymy. For instance, examples such as "Don't let the Gulf become another Vietnam" are clearly outside the scope of such a treatment, mainly because an implicit shared context rather than an explicit verbal semantics shapes the meaning of the utterance. However, the class of *unambitious* metonymy which *is* covered is large enough to view the approach as promising.

6.2 Substitutive Icons and Bridges

Metonymy allows one concept to act as a *proxy* for another, provided the source and target of the oblique reference are conceptually related; for instance, to refer to a book by its author is clearly metonymic. But what does it mean to refer to someone as *red* but mean *angry*, or to call someone *cold* but mean *emotionless*. In each case one concept is used to evoke another, but neither source or target are conceptually related. However, such associations do serve as useful visualizations for abstract notions, and in many cases are actually grounded in physical experience, as with red → anger and hot → passion. Let us denote such visual relations as *iconic* mappings; thus we have iconic(red → angry) and iconic(cold → passionate). We also have useful visualizations such as iconic(rag → poor) {as in "rags to riches"} and iconic(scar → pain) {as in "mental / emotional scars"}.

Core metaphors serve to organize our abstract conceptual structures around experiential world knowledge; for instance, the orientation metaphor Up/Down organizes a whole wealth of polar concepts. We can view this organization as a metaphoric *bridge* crossing from an abstract domain to another, more grounded domain, as with emotion $\rightarrow$ orientation (happy $\rightarrow$ up, sad $\rightarrow$ down) and health $\rightarrow$ orientation (healthy $\rightarrow$ up, unwell $\rightarrow$ down). We extend this notion to define a generalized notion of metaphoric bridge as follows:

direct: bridge(X $\rightarrow$ Y) $\equiv$ iconic(up(Y) $\rightarrow$ up(X)) & iconic(down(Y) $\rightarrow$ down(X))

inverse: bridge(X $\rightarrow$ Y) $\equiv$ iconic(up(Y) $\rightarrow$ down(X)) & iconic(down(Y) $\rightarrow$ up(X))

As shown, bridges can map an abstract concept onto an experiential concept either directly or inversely. For instance, a direct bridge exists between body-temperature $\rightarrow$ emotion, appearance $\rightarrow$ radiance (she was radiant/dull), appeal $\rightarrow$ flavour (she is tasty/ bland) intelligence $\rightarrow$ luminance (she is bright, he is dim), functionality $\rightarrow$ life (the process is alive / dead), user-interface $\rightarrow$ appearance (Motif is pretty), and ease-of-use $\rightarrow$ attitude (UNIX is surly / curt). The inverse bridge is provided for completeness, but a coherence across orientation metaphors means that it is rarely used. We *do* however have iconic(down(Speed) $\rightarrow$ up(Duration)), and iconic(up(Speed) $\rightarrow$ down(Duration)); for example, a quick talk is short in duration, while a slow talk is long in duration.

Metaphoric bridges can be traversed when interpreting associations maintained by the collocation operators, as follows:

connect(X, Y) & iconic(Y $\rightarrow$ Z) $\equiv$ connect(X, Z)

Thus, connect(Linda, Bright) is resolved as connect(Linda, Clever), by following the bridge(Intelligence $\rightarrow$ Luminance) via iconic(Bright $\rightarrow$ Clever).

The attribute transfer mechanisms described in the previous section also employ metaphoric bridges. For example, the metaphor "IBM gave OS/2 a bath" not only implies that OS/2 was originally a *stinker*, but that it now has a much cleaner interface:

actual-cause(IBM, connect(OS/2, Bath)) & Transfer(Bath $\rightarrow$ Clean)

$\equiv$ actual-cause(IBM, connect(OS/2, Clean)) and using bridge(User-Interface $\rightarrow$ Appearance) & Up(Appearance) $\rightarrow$ Clean

$\equiv$ actual-cause(IBM, connect(OS/2, User-Friendly))

The combination of functional attribute transfer and metaphoric bridges also resolves metaphors such as "to give birth to the Snake workstation" (transfer Alive, iconic(alive $\rightarrow$ operative)), and "the death of the PC AT" (transfer Dead, iconic(dead $\rightarrow$ inoperative)).

Effectively, metaphoric icons and bridges are hard-wired mappings from the abstract to the physical domain, from the intangible to the imagable. These mappings are by necessity hard-wired, for they represent a body of acquired cultural, experiential and distinctly *human* knowledge which is simply beyond the inference capabilities of a machine.

7. Relation to Previous and Current Metaphor Research

Current research stresses the role of special knowledge representation in the interpretation of metaphor (see for instance Way 1991, Fass 1991, Martin 1990 and Suwa & Motoda 1991). Some work, such as that of Martin 1990, also stresses the role of metaphor in the language comprehension and acquisition processes, and thus has bearing on the conceptual scaffolding model reported here. Martin's research employs core conventional metaphors, such as that implicit in the many forms of the verb *To Give*, to interpret new metaphors as they occur. In this respect, Martin's system MIDAS is comparable to the Conceptual Scaffolding model. Both models employ what Martin terms the Metaphoric Knowledge Approach, which uses knowledge about known metaphors to provide interpretations for new ones. In a sense, therefore, one might equate the spatial operators of the conceptual scaffolding with the core metaphor representations of MIDAS; however, the MIDAS system does not distinguish between the two stages of interpretation favoured here, that of scaffolding and elaboration.

The model presented in this paper does not represent a return to primitive-based models of language processing, in the mould of Conceptual Dependency theory (CD), (see Schank

1975). Because the scaffolding approach views spatial operators as irreducible semantic *building blocks*, this is a comparison which is hard to avoid. However, Conceptual scaffolding and CD differ in four major ways:

- A scaffolding structure does not claim to capture all nuances and subtleties of meaning inherent in an utterance, merely the broad strokes of that meaning, as a guide to the construction of a more complete interpretation which factors in such issues as context and shared domain.This elaboration may well be a gradual, on-going process, as either new concepts are acquired, or new subtleties of combination are discovered. In this latter respect, the listener brings much of himself to the metaphor, creating an interpretation of far greater subtlety than that originally intended. Conceptual Dependency, however, was advocated as a universal primitive-set capable of capturing the full meaning of an utterance in an altogether more direct fashion, without recourse to an additional elboration process.

- The operators of the spatial semantics are not arbitrary - rather they are based around core spatial metaphors, which as Lakoff & Johnson demonstrate, significantly organize our conceptual processes. This metaphoric nature of the basic operators offers great flexibility in the construction of scaffolding structures and overcomes the problems of rigidity and brittleness in traditional primitive-based systems, such as Conceptual Dependency.

- These operators have a broad spatially-founded semantics, but have no inherent literal meaning independent of the concepts upon which they operate. The interpretation of a particular operator depends on the concepts to which it is applied, to such an extent that the action of the operator can be said to be polymorphic. In contrast, a CD operator such as PTRANS has an a priori literal semantics relating to physical movement which cannot *bend* to accommodate unforeseen (e.g., metaphoric) circumstances.

- A spatial operator only forms part of the final meaning representation when no corresponding conceptual relation can be found, as in the case of novel and creative metaphor. The use of an operator is intended mainly as a guide to the elaboration process, which may *build around* the operator to such an extent that it is no longer required for the final interpretation. This rational contrasts sharply with Conceptual Dependency theory, for while CD structures can act as the basis of further inference, once constructred they remain a fixed part of the meaning structure of the utterance.

Of course, the most obvious difference lies in the design ideology of both systems; Schank originally advocated CD as a set of universal primitives for the representation of all natural language utterances, but gave no special place for metaphor in the CD scheme of things. By thus implying that metaphoric utterances could be fully represented within a literal primitive semantics, Schank essentially subscribed to the substitution view of metaphor, albeit at a lower level of representation. This criticism must apply to all systems which employ primitives with an inherent literal semantics. One such model is that of Suwa & Motoda 1991, which is designed for the acquisition of metaphoric relationships by mapping between systems of semantic primitives. This model allows for high-level semantic constructs which are automatically expanded into an irreducible primitive representation by the system, a notion which shares much with Schank's CD scripts. Again, however, the primitives of Suwa & Motoda differ from the operators of the Conceptual Scaffolding in that they possess an inherent literal semantics. It is such literality which is the cause of inflexibility and brittleness in primitive-based systems, where irreducibility causes a predicate to fail when its usage deviates even slightly from its pre-specified semantics.The Conceptual Scaffolding model overcomes this rigidity by providing operators with a metaphor-based semantics which accommodates concept association even in novel and unspecified situations.

8. Summary & Conclusions

This paper advocates a model of conceptual scaffolding for the robust processing of figurative language. Built upon a spatially-founded semantics, the model exploits the flexibility of idea association to construct representative conceptual structures for both conventional and novel metaphors. We have also seen how, from the basic scaffolding provided by core spatial metaphors, more elaborate interpretations of the metaphors can be achieved by the exploitation of other domain knowledge.

The operators of the spatial semantics are themselves based upon fundamental metaphors of collocation, containment and orientation. In doing this we have realised one implementation of Lakoff & Johnson's proposals about the centrality of core, experiential metaphors in conceptual structuring. The success of this approach here, we think, augurs well for the plausibility of the approach as a model of human metaphor comprehension. It also indicates that the notion has practical significance in the development of robust NLP systems that acquire knowledge directly from natural language text.

An obvious avenue of future research is that of analogical reasoning. We believe that conceptual scaffolding, with its fixed set of spatially-founded operators, is well suited to the task of structural mapping (see Gentner, 1983, Keane 1988); because a spatial operator derives much of its semantics from the concepts to which it is applied (i.e., it is polymorphic), operators may be mapped invariant between domains. On a more pragmatic level, the spatial semantics would be of significant use in an information retrieval context, in which the conceptual content of a body of text could be indexed on its *spatial shape* , simply the uninterpreted scaffoldings (comprising the operators of collocation, containment, orientation and causality) generated from its content. Such a system would be very robust in the face of figurative language, whether it be in the indexed texts themselves or user queries upon those documents.

The conceptual scaffolding model as described herein has been implemented as part of the TWIG concept acquisition from text NLP system (see Cunningham & Veale 1991a, 1991b), on a SPARCstation 2 using common LISP and CLOS.

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