# Invariant Mappings and Contexts in a Computational Approach to Metaphor Interpretation

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## Abstract

We start by characterizing the role of a set of invariant mappings within a semantic framework for metaphor interpretation. Such rules are defaults and have previously been identified by our group as invariant mappings adjuncts to any conceptual metaphor. We provide a formal description of several invariant mappings that transfer information such as causation and event degrees, and discuss some issues with respect to their implementation in a pre-existing AI system (ATT-Meta).

## 1 Introduction

It is generally accpeted that much of everyday language shows evidence of metaphor. Although some work has been done on the semantics of metaphor (Asher and Lascarides, 1995; Stern, 2000), it is not yet clear what the relation is between the semantics and pragmatics of metaphor interpretation from a computational point of view.

We assume the general view that metaphor understanding involves some notion of events, properties, relations, etc. that are transferred from the source domain into the target domain. In this view, a metaphorical utterance conveys information about the target domain. We investigate and account for the transfer of information from source to target as a relation between two computational contexts: the *pretence cocoon* and the *reality*. The ATT-Meta system (Barnden and Lee, 2002) performs *within-pretence inferencing* so that we can derive, from the initial utterance, information that can be transferred into the reality using correspondences provided by the existing conceptual metaphor (in our terminology, "metaphorical view"). In our approach, this reasoning takes place in the special, protected computational context called the "pretence context". We use the term 'reality' to refer to the space in which the information conveyed by a metaphorical utterance is transferred to.

Some authors have tacitly assumed that there is evidence for the existence of aspects that invariably map from pretence to reality, whatever the metaphorical view is in play (Lakoff, 1993). We address the issue in more detail and describe and formalize a set of view-neutral mapping adjuncts (VNMAs) which transfer those aspects that are not part of any specific metaphorical view. Moreover, we claim that VNMAs can be seen as default rules. Furthermore, we introduce a general semantic framework for metaphor by characterizing the meaning relation between the two contexts as consisting of the central mappings provided by the metaphorical view in play, and the set of default rules that transfer invariant aspects from the pretence to the reality.

The next section introduces a general semantic framework for metaphor and discuss the role of VNMAs in such a framework. Section 3 illustrates the notion of within-pretence reasoning in the ATT-Meta approach and system to metaphor interpretation. Section 4 describes two important VNMAs, and in section 5 we present their formalization. We discuss several issues about the implementation of the VNMAs in section 6. Finally, section 7 presents some conclusions and discussion on related work.

## 2 Mappings in a Semantic Framework for Metaphor

We propose to adapt the Situation Theoretic Discourse Representation Theory (STDRT) of Cooper

(1993) to model the transfer of information between contexts in metaphor interpretation (Glasbey and Barnden, 2003). The general idea is to specify the meaning relation $M$ between the pretence and the reality contexts as (roughly) the mappings provided by the metaphorical views and the VNMAs:

$$\text{PRET } [\![\phi]\!]^M \text{ RLT}$$

The informational contribution conveyed by the utterance of $\phi$ in the pretence context PRET is transferred to the RLT context by mapping relations. These mappings take the form of metaphorical views and VNMAs encoded as default rules. VNMAs encapsulate information about properties and relationships of events that map from one context into another. There are events such as "McEnroe starving Connors to death" in a match held at some time $t$ at a location $l$. If we utter "McEnroe starved Connors to death in the 1990 Wimbledon final" and "McEnroe starved Connors to death in the 1991 Wimbledon final" we are referring to two separate events. However, both events have in common the fact that there is some "starving to death" going on between McEnroe and Connors, $starving - to - death(McEnroe, Connors)$.

In this framework, the meaning relation $M$ between the pretence and the reality consists of the central mappings and the VNMAs. Note that the M-relation is context-dependent in the sense that the informational contribution conveyed by the metaphorical utterance will vary according to the contextual and commonsensical knowledge and mappings used. The information conveyed by an utterance may differ depending on which mappings are used by the understander in a specific context. In this paper, a context consists of a set of events $E = (e_1, e_2, e_n)$, a set of relations $R$ between events and a set of properties $P$ of events such that $D = (E, R, P)$. Properties are expressed by relations which take an event and a variable as arguments: $rate(e, r)$. An event is a tuple $e = (r, x, y, \ldots)$, where $r$ is a relation held by at least one individual $x, y$. Reality and pretence contexts are seen as partial structures, that is, unlike the structures of possible world semantics, we do not have complete information about all the propositions that are true of an individual.

## 3 Inference in the Pretence Context

Consider the following example:

(1) "In the far reaches of her mind, Anne knew Kyle was having an affair."

(1) is what we call a map-transcending metaphorical utterance, that is, (1) includes a component – far reaches – in the source (pretence) that, plausibly, is not mapped to a correspondent in the target (reality). The interpretation of this metaphorical utterance may involve talking of IDEAS AS PHYSICAL OBJECTS (A) and MIND AS A PHYSICAL SPACE (B). We assume that (A) provides a mapping between "conscious mental processing and physical manipulation". We could use the mapping to conclude that "Anne physically manipulating an object" maps into "Anne consciously operating on the idea" in the reality. However, (A) is of no direct use in dealing with the "far reaches" aspect of (1).

Instead of attempting the creation of new mappings to extend an existing metaphorical view (Falkenhainer et al., 1989; Holyoak and Thagard, 1989) we employ within-pretence inferencing, which consists largely of reasoning within the terms of the source domain. Avoiding map-extension is a good default because in some cases there may well be no plausible correspondences.

We can reason within the pretence that if some object is difficult to see and/or reach then it is difficult to get hold of it and manipulate it. When a person is physically distant from a physical object then the person usually has only a very low degree of ability to manipulate that object physically. Therefore, assuming that, in the metaphorical conception, Anne is located centrally in her own mind-space, it is possible to reason that Anne has a very low degree of ability to physically manipulate the idea that Kyle was having an affair. We now hope to use the mapping between physical manipulation and conscious mental processing to create the proposition that Anne has only a very low degree of ability to consciously operate on the idea that Kyle was having an affair. The nature of source domain reasoning in metaphor interpretation has not previously been adequately investigated, although a few authors have addressed it to a limited extent (Carbonell, 1982; Hobbs, 1990; Martin, 1990; Narayanan, 1997).

## 4 Invariant Mappings

Note that the metaphorical views involved in our discussion of (1) do not say anything that allows

us to map the *degree* of *ability* to physically manipulate an idea to the *degree* of *ability* to mentally operate on the idea. That is, the mapping in the previous paragraph does not address the *degree* and the *ability*. We could invent a new version of the physical-manipulation/mental-operation mapping that does incorporate *degree* and *ability*, but such enrichment of mappings would be needed for many other mappings as well. What we need is a more general and economical approach that allows us, for other metaphorical views too, to map a), physical manipulation to mental operation, b) *ability* to physically manipulate to *ability* to mentally operate, and c) the *degree* of ability to physically manipulate to the *degree* of ability to mentally operate.

We claim, after some empirical evidence (Wallington et al., 2006), that the mapping of b) and c) are accomplished by using the Causation/Ability and Degree VNMAs, respectively. The use of VNMAs and within-pretence inferencing, we do not need to find a correspondent fo "far reaches", or to extend the mappings in the metaphorical view to include degrees and abilities. Instead, we propose to use VNMAs that transfer those properties or relations between mappees that are view-neutral. VNMAs are parasitic on the metaphorical views in the sense that they depend on some mappings (conditions) to be established for the VNMA to be triggered. Other authors seem to have merely assumed the existence of a special type of invariant mappings (see for example, Lakoff (1993)) but they do not address the issue explicitly, aside from the early work of Carbonell (1982).

Summarizing, the following processes, amongst others, are involved in the understanding of map-transcending utterances in the ATT-Meta approach: A. construction of within-pretence domain meaning of the utterance; B. placing of it in the pretence cocoon; C. source-domain reasoning within the pretence cocoon, using the direct meaning constructed in A. with general knowledge about the source domain; and D., transfers by application of specific mappings in metaphorical views and, often the application of VNMAs specified as default rules.

## 5 Description of VNMAs

We claim that often, VNMAs account for the mapping of aspects of the pretence that do not belong to a specific metaphorical view, but that carry the main informational contribution of the metaphorical utterance. In example (1), the *degree* and *ability* are carried over by the Qualitative Degree and the Causation/Ability VNMAs, which are discussed below (other VNMAs have been uncovered (Wallington et al., 2006) but we limit the discussion to these two for space reasons):

**Causation/Ability**: "Causation, prevention, helping, ability, (dis)enablement and easiness/difficulty relationships or properties of events between events or other entities in the pretence, map to those relationships between their mappees (if they have any) in the reality."

**Qualitative Degree**: "If the holding of a graded property or relationship in the pretence maps to the holding of a graded property or relation in the reality, then the qualitative degrees map over identically. For example, if the presence of high temperature maps to the presence of anger, then the higher the temperature the more intense the anger."

## 6 VNMAs as Default Rules

ATT-Meta is both a pre-existing approach and an implemented system for metaphorical reasoning (Barnden and Lee, 2002). The system is rule-based and performs sophisticated reasoning with uncertainty on the content of metaphorical utterances covering processes C. and D. discussed above. As a reasoning engine, ATT-Meta employs backward reasoning. ATT-Meta uses an event-based language to encode knowledge, including the conversion rules needed in the metaphor interpretation process. The VNMAs described in the previous section express the idea that properties of events or relationships between two events map from the pretence to the reality. Thus, we need to talk about events, relations, properties of events and two type of contextual spaces, the pretence cocoon and reality, so the syntax of the logical language used can simply consist of standard first-order logic extended with variables for reified events.

### 6.1 Causation/Ability

We use the $\mapsto$ symbol to express that the mapping is a default. The Causation/Ability VNMA is used to map *ability* in (1); it expresses the idea that if Anne has the ability to physically manipulate then it has the ability to mentally operate, where *ability* is a quality of Anne.

In this sense, 'Anne having the *ability* to physically manipulate' in the pretence is *viewed* as 'Anne having the *ability* to mentally operate' in the reality, but formally can be considered the same entity (Anne) or event (physically and mentally operating). This is to say that Anne $x$ *having the ability* to physically operate upon $e_1$ in the pretence is *viewed* as some Anne $y$ *having the ability* to mentally operate upon $e_2$ in the reality. The question is a) whether we consider actually using two variables for the same person and two different events, or b), whether we simply preserve the identity across contexts by using the same variable for the agent and the events. These two points of view can be represented as follows:

a) $\forall x, y, e_1, e_2(ability(x, e_1)_{pret} \wedge mapsto(x, y) \wedge mapsto(e_1, e_2) \mapsto ability(y, e_2)_{rlt})$

b) $\forall x, e(ability(x, e)_{pret} \mapsto ability(x, e)_{rlt})$

The first option causes an unnecessary multiplication of entities which can make the implementation of VNMAs a very complex task if we consider not a single utterance but a discourse. In option b), we try to avoid multiplication of entities. This is somehow more consistent with the notion of metaphorical views where we view IDEAS AS PHYSICAL OBJECTS. Furthermore, option b) seems more consistent with the treatment of those terms which denote non-event entities that are present both in the pretence and the reality (such as Anne).

We would also like to stress that the specific mapping of each event variable does not depend on the VNMA but on the metaphorical view in play. In other words, VNMA rules do not themselves establish the mappees between the pretence and the reality. Thus, in the semantic framework introduced in section 2, the meaning relation $M$ that transfers the informational contribution from the pretence to the reality consists of the *VNMAs* and the *central mappings* provided by the relevant metaphorical view.

### 6.2 Qualitative Degree

We have already discussed the "far reaches" example which involved the use of the Qualitative Degree VNMA to map the exact degree of operability from the physical to the mental domain. The logical form of one aspect of this VNMA is as follows:

$$\forall e, d(degree(e, d)_{pret} \rightarrow degree(e, d)_{rlt})$$

## 7 Adding VNMAs to ATT-Meta

Going back to the "far reaches" example, we assume that the surrounding discourse raises the question to what degree Anne can consciously entertain the affair idea. The input consists of the logical form of the (simplified) query (see (Barnden and Lee, 2001)) for details of the event-based formalism used):

(2) to-degree-exactly(D):
can-consciously-mentally-operate-on(anne,
the-idea-that(having-affair(kyle))).

Because of built-in rules about qualitative degrees, ATT-Meta sets up the following two subqueries as a result of investigating (2):

(3) to-degree-at-least(D):
can-consciously-mentally-operate-on(anne,
the-idea-that(having-affair(kyle))).

(4) NOT(to-degree-at-least(NextD):
can-consciously-mentally-operate-on
(anne,the-idea-that(having-affair(kyle)))).

NextD has the additional constraint that should be the degree above D within a scale of degrees (very-low, low, medium, high, very-high, absolute). (3) is the more interesting subquery because it further restricts the value to which *degree* can be instantiated. (4) matches the THEN part of a *conversion rule* of the following (simplified) form:

(5) If NOT(to-degree-at-least(D):
can-physically-operate-on(P,J))
THEN NOT(to-degree-at-least(Degree:
can-consciously-mentally-operate-on(P,J))).

Within-pretence reasoning would then follow the procedure described, in which a conversion rule which corresponds to (5), creates an explicit mapping for *degree* and *ability*. It also ensures that the value of the degree that the variable $D$ is eventually instantiated with will be carried over. ATT-Meta implements the Degree VNMA by including degrees in such individual rules. Moreover, ATT-Meta implements a Negation VNMA by specifying negative versions of each of the individual rules (e.g., (5); we do not include examples of the Prolog expressions for space constraints). The conclusion is a default since the within-pretence conclusion (ideas being physically inacessible), and the conversion rule used is a default rule.

Thus, information of the reality context could potentially defeat the conclusion.

As we argued in the previous section, this implementational approach has the undesirable consequence of having to create new specific rules about *degree* and *ability* for many other mappings of other metaphorical views. In fact, ATT-Meta has been tested to deal with many map-transcending metaphorical utterances (Barnden et al., 2002). We plan to handle degree, ability, etc. by means of separate default production rules. The precise characterization of the IMs to be implemented, and placing them in a semantic framework for metaphor, is the first step towards that goal.

## 8 Concluding Remarks

Map-transcending entities pose a problem for several analogy-based approaches to metaphor interpretation, both from a computational and a theoretical point of view. With respect to the computational approaches, theories of metaphor interpretation based on analogy (Falkenhainer et al., 1989; Holyoak and Thagard, 1989) usually require a conceptual similarity between the source and the target domains. Map-transcending entities need to be mapped by extending on the fly the metaphorical views with new correspondences. We have argued that this strategy is in some cases, plainly impossible.

From a theoretical point of view, several authors have addressed metaphor interpretation: Asher and Lascarides (1995) and Vogel (2001) do not provide a general treatment of map-transcending metaphorical utterances. Although Stern (2000) discusses something similar to within-pretence inferencing in several examples, he does not offer a formal framework and his approach lacks the backing of an implementation.

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