Wiebke Petersen

Tanja Osswald

University of Düsseldorf

Germany

A FORMAL INTERPRETATION OF CONCEPT TYPES AND TYPE SHIFTS

1. *Introduction*

In our paper, we show how type shifts can be analyzed in terms of frames. Our main thesis is that frames are adequate for analyzing type shifts. We show that, as a rule, type shifts are rather simple, not changing much of the structure of a frame. Exceptions occur, but these require a strong context and are close to changing the meaning of the concept itself.

The concept of *frame*, as introduced in Barsalou (1992), is that of a recursive attribute-value structure. Barsalou argues that frames form the general format for the content and structure of concepts in human cognition. The attributes in a frame denote properties of the object described by the concept. Values can be either atomic or frames themselves with their own attributes and values. Formally, frames can be viewed as directed graphs where the edges stand for the attributes of a frame and the nodes depict their values.

Building on Löbner (2010 submitted), concepts can be categorized into four concept types with respect to inherent relationality and inherent referential uniqueness. We show how the different concept types are reflected by the structure of the corresponding concept frame graphs. In language, a concept need not only be used in the type it is lexicalized in but context can coerce it into another type, too, e.g. in ‘Twenty mothers came to the school meeting’, the functional concept *mother* is used as a sortal concept. This phenomenon is called a *type shift*. Type shifts can occur between all four concept types. In our paper, we explain the mechanism of type shifts on the basis of our frame model.

The rest of the paper is structured as follows: In section 2, we give a definition of concept types and type shifts. In section 3, we introduce frames and show how the concept types are reflected in the frame structure. In section 4, we discuss some examples of type shifts. We conclude with section 5, summing up our results.

2. *On concept types*

In Löbner (2010), it is argued that nominal concepts can be categorized along two dimensions: inherent referential uniqueness and inherent relationality. Inherently unique are those concepts that denote exactly one object, like *pope*. Inherently relational are those concepts that need another argument, e.g. a brother is always a brother of someone and a trunk is always the trunk of some tree. This other argument is called *possessor*, although the relation is not necessarily an ownership-relation.

With these distinctions, we get a fourfold classification (see Table 1): *Sortal concepts* (e.g. *tree*) are non-unique and non-relational. They denote classical concepts. *Individual concepts* (e.g. *Mary*) are non-relational but they are unique. Proper names and definite descriptions are individual concepts since they denote a specific entity. *Proper relational concepts* (e.g. *brother*) are non-unique but relational, while *functional concepts* (e.g. *meaning*) are both, unique and relational. That is, functional concepts have a unique referent dependent on the potential possessor. Together, the last two concept types form the class of relational concepts.

Table 1. Concept types according to Löbner

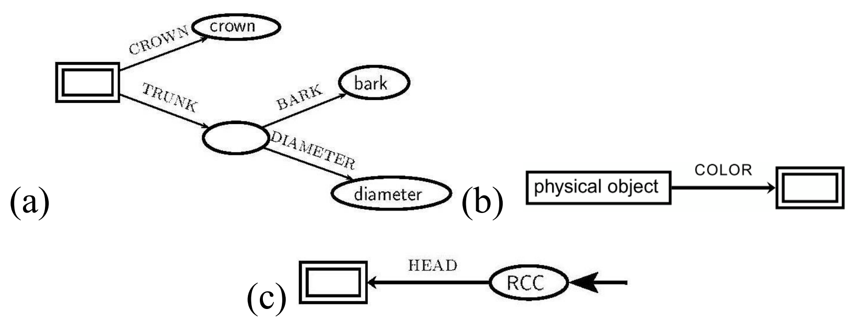
	non-unique reference	unique reference
non-relational	sortal concept	individual concept
relational	proper relational concept	functional concept

Concepts are not always used as their lexicalized concept type dictates. In the case the realized concept type differs from the lexicalized concept type, we speak of a *type shift*. In these cases, the concept is not used as determined in the lexicon; rather context forces it to be of another concept type. We argue that these shifts occur frequently and can range over all concept types.

3. *On frames*

Frames are attribute-value structures, a generalized form of feature structures. The idea behind our frame model stems from Barsalou (1992), who established frames as a “fundamental representation of knowledge in human cognition”. A formal account of frames is given in Petersen (2007). Frames can be represented by directed connected graphs that satisfy the following conditions: One node is marked as the central node (depicted by a double border). Nodes can be labeled with types (indicating the sort of the value) and arcs are labeled with attributes. These attributes are functional, i.e. there is no node with two outgoing arcs with the same label. Frames can have open arguments; these are depicted by rectangular nodes. Uniquely referring nodes have a definiteness marker.

Figure 1. (a) Frame for the sortal concept *tree*, (b) frame for the functional concept *color* and (c) frame for the individual concept *pope*



For example, the frame for *tree*[1] in Figure 1(a) has one open argument, the central node itself. The argument has two attributes, CROWN and TRUNK, the value of the latter of which has two attributes in turn, BARK and DIAMETER. This little example shows one important feature of frames: They are recursive. When analyzing a concept, it is possible to decompose a concept to any degree of detail by decomposing each node of it in turn.

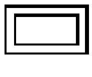
[1] Note that all our frame graphs are highly simplified. We do not claim to give full reconstructions of the concepts modeled; we argue about their structural properties.

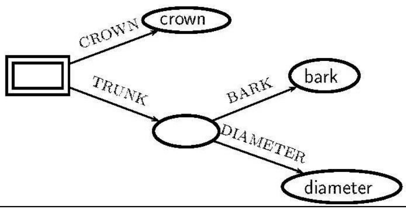
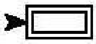
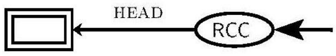
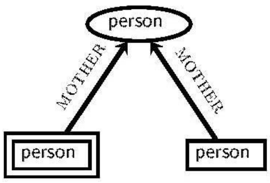
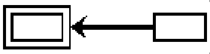
Furthermore, CROWN is a function which has as its range the set of crowns, so the label of the node is superfluous and just serves readability. In Figure 1(b), we have the case of an open argument that is not the central node. The type of the open argument carries a constraint, i.e. that just physical objects can have a color. Such constraints are formulated in a type signature (cf. Petersen 2007). In Figure 1(c), the node labeled RCC (roman catholic church) has a definiteness marker since it is a proper name.

Frames are not represented by arbitrary graph structures; their attributes have to be functional. Thus, attributes correspond to functional concepts. Or, seen from another angle: Each concept is decomposable into functional concepts. So, functional concepts form the basis of all concepts.

What makes frames useful for an analysis of concept types is that the type of the concept is reflected in the frame structure (Table 2): Inherent relationality is marked by having another open argument, besides the central node. A frame is referentially unique if (i) its central node is marked by a definiteness marker or (ii) there is a directed path from a node marked by a definiteness marker to the central node or (iii) there is a directed path from an open argument node to the central node. In case (i) and (ii), we have a frame for an individual concept, while in case (iii), it is a frame for a functional concept: when the open argument is filled, it uniquely determines the central node's reference. For example, the tree frame in Figure 1(a) has one open argument (the central node) and no incoming arcs at the central node, in particular none from a definite node. Thus, it is the frame of a sortal concept. The color frame in 1(b) has two open arguments and there is a directed path from the second open argument node to the central node. Thus, it is the frame of a functional concept. The pope frame in 1(c) has one open argument and there is a directed path from a node with a definiteness marker to the central node. Thus, it is the frame of an individual concept. Table 2 gives a summary of concept types and their corresponding frame properties.

Table 2. Concept types in frames (*u* is short for referentially unique and *r* is short for inherently relational)

concept type	u	r	most simple graph	example	frame properties
sortal	-	-		tree	one open argument (= central node)

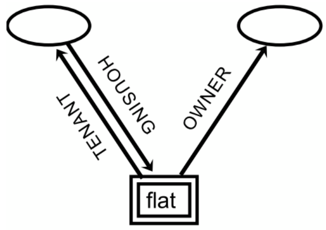
					no path from a definite node to the central node
individu al	+	-		 pope	one open argument (= central node) there is a direct path from a definite node to the central node
proper relationa l	-	+		 sibling	two open arguments no path from a definite node to the central node
function al	+	+		 mother	two open arguments there is a direct path from the other open argument to the central node

4. *On type shifts*

In language, concepts can be used in any concept type, not just the one they are lexicalized in. If the realized concept type differs from the lexicalized concept type, we call this phenomenon a *type shift*. Type shifts occur frequently in language and can go from each type to each type – with less or more context needed to make the shift acceptable.

As an example, regard the concept *flat*. Keeping things simple, we analyse flat as having an owner and a tenant who in turn has the flat as his housing (see Figure 2). As we see, there is one open argument and no incoming arc from a definite node at the central node, thus the concept is sortal.

Figure 2. A frame for the sortal concept *flat*



Still, ‘flat’ can be used in different ways, as the following examples show.

(1) Many flats are offered in the newspaper.

(2) This flat is one of John’s, he owns more than five.

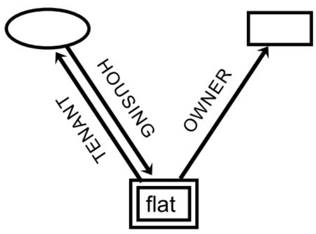
(3) The flat of Mary is huge and the rent is reasonable.

(4) The flat is up for rent.

Only (1) is an example of a sortal use of flat. In the other examples, the realized concept has its type shifted.

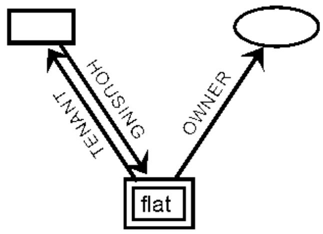
In (2), the owner of the flat is given, so the frame model for *flat* needs to have an open argument for the owner (Figure 3). There cannot be an arc from *owner* to *flat*, since the owner can own more than one flat. Thus, the resulting frame is proper relational. The shift from sortal to proper relational consists in opening one frame component as a new argument.

Figure 3. Frame for the proper relational concept *flat*



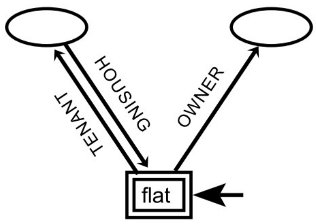
In (3), we need the argument for the tenant to be open (Figure 4). Now, we have an arc from the tenant argument to the central node. Thus, the concept is realized as being functional. In contrast to the relation to the open argument in Figure 3, the relation between a flat and its tenant is one to one (remember that our examples are highly simplified). As for the proper relational case, the type shift from sortal to functional consists in opening one frame component as a new argument.

Figure 4. Frame for the functional concept *flat*



In (4), some context information is necessary to indicate which flat is talked about. In the frame, this is reflected by a definiteness marker (Figure 5). There is no second open argument and the central node is definite, so the realized concept is individual. The type gets shifted from sortal to individual by the introduction of the definiteness marker.

Figure 5. Frame for the individual concept *flat*



To see that concept types are not just shiftable from sortal concepts, regard the concept *mother*. Simplified, a mother is the mother of someone (see Figure 6). There are thus two open arguments and the argument that does not correspond to the central node determines the value of the central node. So, *mother* is a functional concept.

Figure 6. Frame for the functional concept *mother*

As with flat, mother can be used in non-lexicalized forms. Regard the following examples (cf. Gerland & Horn, 2010).

(5) Maria is Peter's mother.

(6) Maria is a mother.

(7) Maria is the mother.

(8) ?Maria is a mother of Peter.

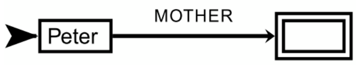
In (5), *mother* is used functional, as lexicalized (see Figure 6). All other examples include a type shift.

In (6), we can assume a context like "These are the teachers and parents of class 2b. Maria is a mother." indicating that Maria belongs to the group of parents. The possessor of the concept is irrelevant in this context, the central node is the only open argument (Figure 7). Since there is no indicator of definiteness (the incoming arc does not come from a definite node), the realized concept is sortal. The shift from functional to sortal consists in closing the second open argument.

Figure 7. Frame for the sortal concept *mother*

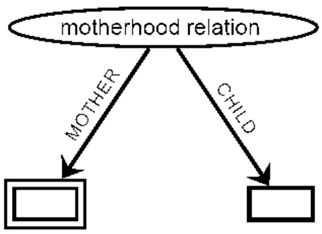
Example (7) is acceptable in a context like "Peter is a scrawny boy. Maria is the mother." Here, the possessor is instantiated (Figure 8) and its unique reference is marked by a definiteness marker. Thus, the concept is realized as individual. The type shift from functional to individual closes the second open argument. Thereby, the unique reference from the functional concept gets lost, but it is replaced by a definiteness marker which – via a path of length one - uniquely determines the referent of the central node.

Figure 8. Frame for the individual concept *mother*



Example (8) is slightly marked. It can be understood but is a little off. Here is a context which works "Peter's parents are a lesbian couple. Maria is a mother of Peter." In this context, the mother is not uniquely determined by the child anymore, one child can have more than one mother. *Mother* still has a possessor, so there has to be a second open argument. This must not determine the central node, so we have to introduce a motherhood-relation that connects child and mother without a direct path between them (Figure 9). Thus, *mother* is realized as proper relational. In this case, the type shift from functional to proper relational rebuilds the whole structure of the frame: A direct link is replaced by a new node with two arcs.

Figure 9. Frame for the proper relational concept *mother*



5. *Conclusion*

As we have seen, type shifts occur frequently in language and they can range across all concept types. Furthermore, we have seen that not only the concept type but also the type shift can be modeled in frames. Strong context shifts are those that change the structure of the frame considerably (e.g. (8)). In such cases the question arises whether we still have a systemic type shift, i.e. a shift that can be assigned productively on other concepts or whether a new concept is constructed with its own lexical entry. So, changes in the frame structure might indicate polysemy.

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