Chapter 11
Concept Composition in Frames: Focusing on Genitive Constructions

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Abstract In this paper, we show how frames can be employed in the analysis of genitive constructions. We model the main approaches in the discussion about genitive constructions, i.e. the argument-only approach, the modifier-only approach and the split approach. Of these three, the split approach is modeled most naturally in frames. Thus, if frames are considered a cognitively adequate representation of concepts, our analysis supports the split approach to the interpretation of genitive constructions.

Keywords Genitive constructions • Frames • Concept composition

11.1 Introduction

In this paper, we give an analysis of genitive constructions in frame theory. Frames give a decompositional account of concepts. Thus, they are useful for representing single concepts. In the following, we give an example of how to apply the frame approach to operations on concepts. Our example is to model genitive constructions. In a nutshell, genitive constructions can be interpreted as arguments or as modifiers. We show that both interpretations can be modeled with frames. Still, for some genitives, it is easier to model them as arguments; for others it is easier to model them as modifiers. Thus, given that frames are cognitively adequate, frame theory favors a split approach to the interpretation of genitive constructions.

Following Partee and Borschev (2003), we refer to the constructions in focus as *genitive constructions*, although we consider a broader range of constructions

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which do not always involve syntactic genitives. In addition to the clear genitives in phrases like 'John's father' or 'John's car' our analysis also covers phrases like 'the father of John' or 'a brother of John's'.[1] Alternatively, we could have used the term *possessive phrases* instead. This term is syntactically more adequate but it is semantically inadequate since not all relations involved in such phrases are relations of possession: John's father is not possessed by John and Miro's picture may be in the possession of Miro, but it may also be painted by him or depict him. Since our aim is to contribute to the semantics and not the syntax of the phrases under consideration we have chosen to use the semantically neutral term *genitive construction*.

For a better understanding of the subject, we will briefly sketch the main lines in the discussion on the interpretation of genitive constructions. For a more detailed overview refer to Partee and Borschev (2003). The discussion concentrates on how to explain the difference in acceptability of the following constructions (cited from Partee and Borschev 2003, p. 69):

(1) a. John's team
  b. a team of John's
  c. That team is John's.

(2) a. John's brother
  b. a brother of John's
  c. (#) That brother is John's.[2]

The data suggests that not all nouns allow for a genitive in predicate position, e.g. (2c); at least not without a strong context (cf. Partee and Borschev 2003). A related phenomenon can be found in genitive *of* phrases (cited from Søgaard 2006, p. 88):

(3) a. (#) the knife of Shakespeare
  b. the sister of Shakespeare

As there is no difference in the construction of the genitive phrases, it appears that the difference in acceptability of (1c) versus (2c) and of (3a) versus (3b) can only be explained by the different relational status of the main nouns. Relational nouns like 'brother' and 'sister' carry an open argument position which needs to be filled, while

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[1]The former construction 'brother of John' is often referred to as a 'postnominal genitive *of* phrase' (Barker 2011). Whether the latter construction 'a brother of John's' is a genitive construction is controversial. While some, including Partee and Borschev (2003), classify 'of John's' as a postnominal Saxon genitive, Barker (2004) and others argue that it is not a true genitive but a partitive construction.

[2]Throughout this paper, we will concentrate on examples in which the main NP consists of a single noun. More complex NPs which involve relational adjectives, e.g., 'John's favorite movie', will not be considered in detail here.

nonrelational nouns like ‘team’ and ‘knife’ do not.[3] The data shows that predicative genitives (like (1c) and (2c)) require a nonrelational noun while genitive *of* phrases demand the main noun to be relational. Typological evidence for the phenomenon that the relational status influences the acceptability of genitive phrases has been reported for many languages: For example, Partee and Borschev (2003) focus on Russian, English and Polish, Hartmann and Zimmermann (2003) on adnominal genitives in German, and Søgaard (2006) presents a comparative typological study for the two concepts ‘book’ and ‘food’ for eight languages.

Concerning the acceptable examples (1a) and (2a), (1b) and (2b) respectively, the question arises as to why these parallel constructions are possible with relational as well as with nonrelational nouns. Two answers are possible: either the genitive constructions in the (1)-examples differ implicitly from the ones in the (2)-examples, or the nouns are shifted to one uniform relational type and are all subject to the same construction. In the first case, we have one genitive construction with nouns acting as modifiers ((1a) and (1b)) and another genitive construction with nouns acting as arguments ((2a) and (2b)). This analysis is known as the *split approach* (cf. Partee 1983/1997, Partee and Borschev 2003). In the second case, we would either assume a modifier-only construction or an argument-only construction and the nouns would be shifted accordingly before they enter the genitive construction. That is, in a uniform argument-only approach all nouns are shifted such that they become relational (cf. Jensen and Vikner 1994, Vikner and Jensen 2002, Partee and Borschev 1998) while in a uniform modifier-only approach the genitive in a genitive construction always acts as a modifier of the head noun independently of its relational status (for a discussion of the consequences of such an approach see Partee and Borschev 2003).

The relational status of the head noun in a genitive construction not only influences its acceptability but also influences the ambiguity of genitive phrases:

(4) a. John’s brother
  b. John’s team
  c. John’s stone

In some cases, there is a strongly preferred relation, e.g., in (4a), the relational noun ‘brother’ strongly forces the interpretation in which John is an argument in the brotherhood relation. Other readings, for example, those involving a possession relation, are suppressed and need a very strong context: take, for example, the setting of the production team of a documentary about brothers of famous women. This setting enables the following statement: “The brother I am interviewing is jealous of his sister, but John’s brother isn’t.”

Example (4b) does not have a strongly preferred default reading and thus is highly ambiguous: John may be the coach of the team, a member or a supporter

[3] A deeper discussion of the relational status of nouns follows in Sect. 11.2.2. A comprehensive discussion is given in Löbner (2011).

of the team, or he may manage the team. A standard account to explain this kind of variability in interpreting genitive constructions with nonrelational nouns is to make use of the *qualia structure* (Pustejovsky 1995) of these nouns. This qualia structure contains the relations leading to the different interpretations (e.g., Vikner and Jensen 2002, Søgaard 2006). Which relation is picked out for the genitive construction is down to context.

Although example (4c) also involves a nonrelational noun, its qualia structure does not provide any relations fit for a genitive construction. Thus, the only available reading without context is the possessive reading, where John actually possesses the stone. Again, context can make almost arbitrary readings possible: it could be that John sat on the stone, that he likes to look at it at the beach, that he had painted it or that it had dropped on his foot. All these relations between John and the stone come from context and are not part of the 'stone' concept. Thus, example (4b) is the only intrinsically ambiguous genitive phrase of the three.

To generalize from the examples, the question of the argument-modifier distinction and the interpretation of genitive constructions depends on the sort of relation involved. The two participants (often: possessor and possessum) in a genitive construction are related and this relation can either be introduced by the possessum or come from a separate source. A noun in possessum position can be relational, like 'brother', or nonrelational, like 'stone'. In the first case, the relation between possessum and possessor in a genitive construction is referred to by Partee and Borschev as *inherent*, in the second case, it is referred to as *free*.

For nonrelational possessums, we propose a further distinction: some nonrelational nouns are *weakly relational* in the sense that they can have a relation established that is not obligatory (as in example (4b)). That is a relation that does not demand an argument but which, under certain circumstances, can open an argument position which can be filled by the genitive. In these cases, we speak of a *shift* of the nonrelational noun to a relational one. So, overall, we assume three types of nouns: relational nouns (as in (4a)), weakly relational sortal nouns (as in (4b)) and pure sortal nouns (as in (4c)).

Similar proposals have been made in Vikner and Jensen (2002) on the basis of qualia structures. Jensen and Vikner (2004, p. 6f.) propose a fourfold semantic distinction of relations in genitive constructions, exemplified by the phrase 'the farmer's picture' (p. 7). An *inherent relation* (in Jensen and Vikner's terminology) leads to an interpretation where the possessor is an intrinsic aspect of the possessum (the picture depicts the farmer). The *producer relation* states that the possessor has produced the possessum (the farmer has painted the picture). The *part-whole relation* is in place if the possessum is a part of the possessor (e.g., 'the farmer's hand'). The forth relation is called *control relation*. This relation does not stem from the possessor or the possessum but comes from the genitive itself (the picture is owned by the farmer). In our terminology, the control relation is the default for genitive constructions with pure sortal nouns as the possessum. The other three relations are used with relational and weakly relational sortal nouns.

The decompositional concept analysis via frames models the relations expressed by the nouns in the lexicon explicitly, whether they stem from a relational noun or from a weakly relational sortal noun. Thus our frame-based approach can be seen as an extension of the qualia approach. While qualia structures enrich the lexical noun entries by adding a restricted set of qualia which are borrowed from the thematic roles of verbs, like agentive qualia or telic qualia, frames can exhibit a much more complex structure (cf. Sect. 11.2). In our paper, we show how the two main approaches to analyzing genitive constructions are modeled in frames. It turns out that a split approach between argument and modifier analyses is the most favored from the frame point of view.

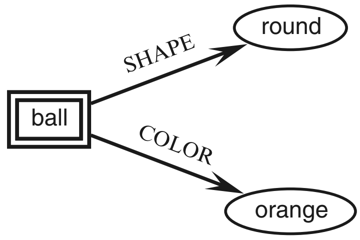
The rest of the paper proceeds as follows: in the next section, we introduce our theory of frames, Löbner's conceptual classes and his analysis of their composition. In the third section, we model the different interpretations of genitive constructions in frames. In the last section we discuss our results.

11.2 Frames

In this section, we give an introduction to frames, conceptual classes and frame composition. Frames are a general format for describing concepts. They are decompositional, that is, they model the inner structure of concepts. One of the main motivations to employ frames in concept analysis is that they are supposed to be a cognitively adequate representation of concepts (Barsalou 1992). Linguistic evidence for this is presented in Löbner (this volume); a neurological model for frames is developed in Petersen and Werning (2007). As Barsalou's cognitive approach is not formal, the formal basis of frame theory lies in the theory of feature structures as presented in Carpenter (1992).

Feature structures encode concepts by decomposing them into attributes and values. They are usually written in a bracket notation but for our purposes we represent them as a connected directed graph with one central node. All nodes are labeled with types and all arcs are labeled with attributes. The attributes denote properties of the object described by the concept. Their values can be given explicitly or be left unspecified. In the latter case, just a type is given. A feature structure has two structural constraints: (a) no node can have two outgoing arcs with the same label, that is, each attribute is functional; in a fully specified feature structure it takes a unique value. (b) The central node is a root of the graph, that is, each node is reachable from the central node by a path following the direction of the arcs.

For example, in Fig. 11.1, we have the concept 'basketball' analyzed as being of type ball and having a round shape (in contrast to the oval shape of a football) and



$$\begin{bmatrix} \text{ball} & \\ \text{SHAPE} & \text{round} \\ \text{COLOR} & \text{orange} \end{bmatrix}$$

Fig. 11.1 The sortal concept 'basketball' in frame notation and in feature structure notation an orange color. In the graph notation, the type of a node is written into the node. The type of the central node gives the sort of the objects denoted by the concept: A basketball is a ball. The central node is marked by a double border. The labeled arcs represent the dimensions along which the concept is decomposed. Here, we regard the shape and color of the ball. As extra notational markers, round nodes stand for satisfied arguments and rectangular nodes stand for open arguments in the frame. In particular, the central node is usually rectangular.[4] Please note that all example feature structures and frames throughout this paper are highly simplified, as we are concerned with structural properties and not with concrete representations of lexical concepts. The small example in Fig. 11.1 is not recursive, but obviously the values of an attribute can be complex feature structures themselves, having their own attributes.

The possible types of nodes are given in a *type signature* which may be considered as being an ontology covering the background or world knowledge. The type signature conveys two kinds of information: first, it gives a hierarchy of all admissible types. Second, it states appropriateness conditions for the types which specify domain and range of attributes. That is, the type signature tells which sort of entities can have a certain attribute and of which type the value of each attribute is. In the example in Fig. 11.1, an underlying type signature may be assumed which specifies that the shape-relation holds between a physical object and a shape as well as that the type ball is subsumed by the type physical object and thus that the shape-attribute is appropriate for objects of type ball, too. In the following, if a type is not mentioned explicitly, it is assumed to be the appropriate type from the type hierarchy. In particular, the type of a node can be omitted if it is uniquely determined by the appropriateness conditions in the type signature.

We propose a generalization of features structures because they can just model a limited (albeit huge) range of concepts; i.e. those that can be modeled by a graph whose central node is the root of the graph. For example, we can model a concept like 'basketball' as a feature structure (see Fig. 11.1) but not a concept like 'flatmate'. A flatmate is someone who shares an accomodation with (at least) one other person. The natural way to model this is to introduce nodes for both flatmates and link them to the same accomodation. The resulting graph is shown in Fig. 11.2. Here, the central node is not the root of the graph. In fact, the graph does not have a root at all.

Taking this into account, we can formally define a frame as a directed, connected graph with nodes labeled by types and arcs labeled by attributes. The attributes are functional; i.e., each attribute can label at most one outgoing arc of a node. One of the nodes of a frame is marked as a central node and the set of nodes has a subset of argument nodes. Graphically, the central node is marked by a double border and the argument nodes are marked by a rectangular border. In Löbner's terminology, the

[4] Exceptions occur when the node's referent is uniquely determined, as will be discussed in Sect. 11.2.2.

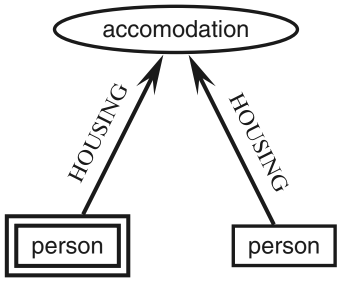


Fig. 11.2 A frame for the proper relational concept 'flatmate'

central node stands for the *referential argument* (cf. Löbner this volume). It refers to the extension of the concept.

In the following, we give a description of a frame in the λ-calculus (Sect. 11.2.1). We then introduce Löbner's *conceptual classes* (Sect. 11.2.2) and show how these classes are shifted if context enforces it (Sect. 11.2.4). We conclude the section by giving Löbner's account of concept composition with respect to the conceptual classes involved (Sect. 11.2.5). This will give us the background for analyzing genitive constructions in terms of frames (Sect. 11.3).

11.2.1 The Associated λ-Expression

Traditionally, the lexical semantics of a concept is expressed by predicate logic. As frames model the semantics of concepts, they can be described in predicate logic. As the λ-calculus can express terms, each frame has an *associated λ-expression*.[5]

The associated λ-expression is constructed as follows. For each open argument, a λ-variable is introduced, the λ-variable for the central argument being the innermost one in the λ-term. For each type p, a predicate P is introduced. For each attribute $\textsc{r}$ a relation R is introduced. The λ-expression is a conjunction of all information in the frame, going through all nodes starting with the central node. For example, the associated λ-expression for the 'basketball' frame in Fig. 11.1 is

$$\lambda x.\, \mathsf{ball}(x) \wedge \mathsf{round}(\textsc{shape}(x)) \wedge \mathsf{orange}(\textsc{color}(x)).$$

As not all nodes of a frame need to be reachable by a path from the central node, we have to provide for the case of a closed node that is a source in the frame graph. In this case, an ε-term is introduced to be able to address the node.

For example, the frame in Fig. 11.3 has the following associated λ-expression:

$$\lambda x.\, \mathsf{trunk}(x) \wedge \mathsf{bark}(\textsc{bark}(x)) \wedge \mathsf{girth}(\textsc{girth}(x)) \wedge \mathsf{tree}(\varepsilon u.\, \textsc{trunk}(u) = x).$$

[5]Note that this expression is not unique. We do not regard the dual question of which fragment of the λ-calculus is expressable by frames.

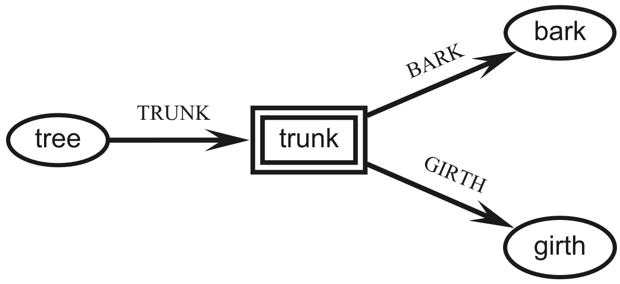


Fig. 11.3 A frame with a non-open source node: 'trunk' as a sortal concept

Table 11.1 Concept classification according to Löbner

	nonunique reference [−U]	unique reference [+U]
nonrelational [−R]	**sortal concept** $\langle e,t\rangle$	**individual concept** $\langle e\rangle$
relational [+R]	**proper relational concept** $\langle e,\langle e,t\rangle\rangle$	**functional concept** $\langle e,e\rangle$

11.2.2 Conceptual Classes

There are several classes of concepts that do not fit well into the feature structure format. Löbner (2011) proposes four *conceptual classes*.[6] These classes sort concepts with respect to inherent relationality and inherent referential uniqueness.

Löbner (1985, 2011) argues for a fourfold classification of concepts. In this, he relates two twofold distinctions: the distinction between inherently unique, [+U], concepts and not inherently unique, [−U], concepts and the distinction between relational, [+R], concepts and nonrelational, [−R], concepts. For example, 'pope' is inherently unique as there is only one pope (at a given time) while 'house' is not inherently unique. We follow Löbner (this volume) in that inherently unique concepts need not be seen as predicates. The second distinction is about relationality. Relationality means that a concept bears an inherent relation – to satisfy it, at least two entities have to be specified: one that falls under the concept and one that stands in a certain relation to the first entity.

These two dimensions are independent of each other (cf. Table 11.1), so there is a fourfold classification: *sortal concepts* (short: SC) are not inherently unique and nonrelational, in short [−U] and [−R]. They are of type $\langle e,t\rangle$ and of the logical form $\lambda x.\ P(x)$. For example, the concepts 'house', 'birch' and 'ball' are sortal concepts; they are neither inherently unique nor do they define an inherent relation. *Individual concepts* (IC) are inherently unique and nonrelational, in short [+U] and [−R], as proper names and definite descriptions. They are of type $\langle e\rangle$ and of the logical form $\iota u.\ P(u)$. For example, the concepts 'Mary', 'pope' and 'sun' are individual concepts. They do not have an inherent relation and their referents are uniquely determined. *Proper relational concepts* (RC) are not inherently unique but

[6]He calls them *conceptual types* but to avoid confusion with the type hierarchy and with logical types, we stick to 'classes' in this paper.

Fig. 11.4 A frame for the sortal concept ‘woman’

Fig. 11.5 A frame for the functional concept ‘mother’

relational, in short [−U] and [+R]. They are of type $\langle e, \langle e, t\rangle\rangle$ and of the logical form $\lambda y \lambda x.\ R(x, y)$. For example, the concepts ‘brother’ and ‘friend’ are proper relational. They are not inherently unique; there can be more than one brother and more than one friend for a given ‘possessor’. They are inherently relational, as a brother is always the brother of someone and a friend has to be the friend of someone. *Functional concepts* (FC) are both inherently unique (relative to a given possessor) and relational, in short [+U] and [+R]. They are of type $\langle e, e\rangle$ and of the logical form $\lambda y.\ f(y)$. For example, the concepts ‘mother’ and ‘shape’ are functional. As soon as the child or the object are given, the mother and the shape are determined, so they are inherently unique. They are relational because they depend on the particular child and the particular shape.

11.2.3 Concept Classes in Frames

The conceptual classes are reflected in the structure of frame graphs as we will see in this section. Figure 11.4 shows a frame of the sortal concept ‘woman’ which can be paraphrased as: something that is a person and that has a female sex, in short: a person that is female. The corresponding λ-expression is

$$\lambda x.\ \mathsf{person}(x) \wedge \mathsf{female}(\textsc{sex}(x)).$$

‘Woman’ is neither a unique nor a relational concept. Thus, in the corresponding frame, there is no open argument besides the central node. And there is no path from a determined node to the central node. λ-expressions of sortal concepts are of the form $\lambda x.\ P(x)$ where P is a one-place predicate which may be arbitrarily complex.

The frame in Fig. 11.5 for the functional concept ‘mother’ can be read as follows: something that is a person that is female and has something else that is a person and that it is mother of; in short: a female person who is mother of another person. The corresponding λ-expression is

$$\lambda y.\ \iota u.\ (\mathsf{person}(u) \wedge \mathsf{female}(\textsc{sex}(u)) \wedge \mathsf{person}(y) \wedge u = \textsc{mother}(y)).$$

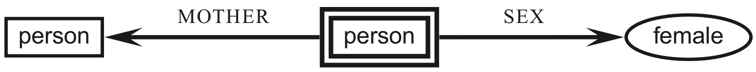


Fig. 11.6 A frame for the proper relational concept 'daughter'

This frame differs from the 'woman'-frame in Fig. 11.4 in that the central node is not the root of the frame graph. Rather it has an incoming arc labeled MOTHER indicating that the referents of the central node are functionally dependent on referents of the open argument node. If this argument is filled with something of type person, the actual referent of the concept is determined (each person has a unique mother). Thus, the central node is closed because it is determined by the open argument node. In the following, we will refer to $\lambda y.\ f(y)$ as the default λ-expression for functional concepts although, as our example indicates, the actual expressions may be extended by further sortal restrictions on the variables.

Figure 11.6 shows a frame for the proper relational concept 'daughter'. It is similar to the frame for 'mother' with just the direction of one arc changed. Thus, it can be read as: something that is a person that is female and has something else that is a person and is its mother,[7] in short: a female person that has a mother. The corresponding λ-expression is

$$\lambda y \lambda x.\ \mathsf{person}(x) \wedge \mathsf{female}(\textsc{sex}(x)) \wedge \mathsf{person}(y) \wedge y = \textsc{mother}(x).$$

Again, we have a relation requiring another entity, marked by an open argument, to satisfy the concept. Yet the referent of the central node is not functionally determined by the referent of the open argument, since there is no arc pointing from the latter to the former, so the concept is not unique (a mother can have more than one daughter). Thus, the central node is open. Though seen strictly, there are no nonfunctional relations in a frame (since all attributes are functional), for simplicity of notation we allow for arbitrary relations in our λ-expressions. The default λ-expression for proper relational concepts is thus $\lambda y \lambda x.\ R(x, y)$. R might correspond to different frames but all statements we make with the arbitrary relation will hold for all kinds of attribute constructions such a relation could stand for.

Figure 11.7 gives a frame for the individual concept 'pope'. The pope is modeled as something which is the head of the Roman Catholic Church:

$$\iota u.\ u = \textsc{head}(\iota v.\ \mathsf{RCC}(v))$$

The unique reference of 'Roman Catholic Church' is modeled in the frame graph by the big arrow pointing at the node labeled RCC. Its uniqueness in turn determines the

[7] Again, please note that our examples are highly simplified.

Fig. 11.7 A frame for the individual concept 'pope' (*RCC* stands for Roman Catholic Church)

referent of 'head of RCC', i.e., of 'pope', uniquely. Because there is a directed path from a definite node to the central node, the central node is closed. λ-expressions for individual concepts are of the form $\iota u.P(u)$.

As the examples discussed above indicate, the concept classification is well-reflected in the corresponding frame graphs. If there is no open argument besides the central node, the concept is nonrelational, if there is such an open arugment, it is relational. Unique reference is encoded by a directed path from a determined node to the central node. Such a node can either be the noncentral open argument node, as for functional concepts, or it can be a node that is explicitly marked as being uniquely referring (big arrow), as for individual concepts. In the latter case, the path can be of zero length, i.e., the central node itself can be marked.

11.2.4 Class Shifts

Although it is assumed that each concept has a conceptual class it is lexicalized in (cf. Löbner 2011), context can force a concept into another conceptual class. We will call this a *class shift*. This shift is also called *type shift* in Löbner (2011)[8] or *coercion* (e.g., Pustejovsky 1995). Shift operations exist on all pairs of concept classes, as is discussed in more detail in Petersen and Osswald (2012). In (Barker 2011, p. 10ff.), several *class shifters* are discussed, in particular relativizers that shift concepts from nonrelational to relational such that they can be used in possessive constructions.

For example, regard the concept 'flat' and its frame graph in Fig. 11.8. A flat is seen here as something that has a landlord and a tenant. In turn, assuming that one person only rents one place, the flat is the tenant's housing, which is modeled by the housing-attribute pointing from the left person-node to the central accommodation-node. In its lexicalized use, 'flat' is sortal, as in

(5) It is more romantic to live in a houseboat than in a flat.

The information expressed in the frame is in logical notation

$$\lambda x.\mathsf{flat}(x) \wedge \mathsf{person}(\textsc{landlord}(x)) \wedge x = \textsc{housing}(\textsc{tenant}(x)) \\ \wedge\, \mathsf{person}(\textsc{tenant}(x)).$$

[8]Remember that Löbner calls 'type' what we call 'class'.

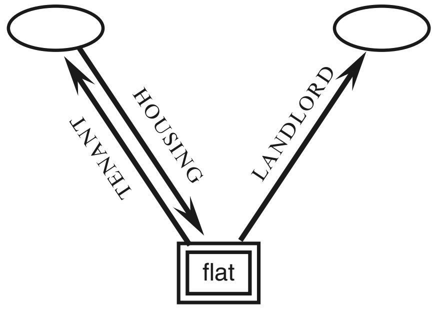


Fig. 11.8 'Flat' as a sortal concept

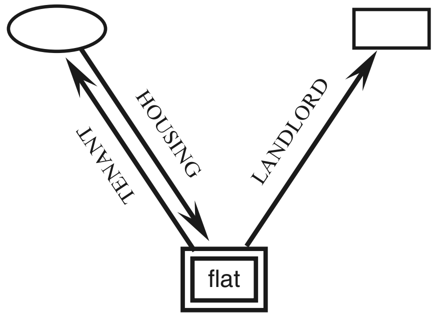


Fig. 11.9 'Flat' as a proper relational concept

Although 'flat' is lexicalized as a sortal concept it can be easily used in a relational context. In other words, depending on the context, 'flat' can be shifted to a different concept class. For a proper relational use, regard the following:

(6) This is a flat of John's; he rents it out to a family of five.

Here, the landlord is explicitly given as an argument. Hence, in the frame for the shifted concept, the value node of the landlord-attribute becomes an argument node (Fig. 11.9). Note that 'flat' is not an attribute value of 'landlord' since one person can own more than one flat. Thus, the frame of the shifted concept fulfills the criteria for a frame of a proper relational concept. In λ-notation, the frame expresses

$$\begin{aligned}\lambda y \lambda x.\ &\mathsf{flat}(x) \wedge \mathsf{person}(\textsc{landlord}(x)) \wedge y = \textsc{landlord}(x)\\ &\wedge x = \textsc{housing}(\textsc{tenant}(x)) \wedge \mathsf{person}(\textsc{tenant}(x)).\end{aligned}$$

Additionally, the concept 'flat' can undergo an alternative shift in which not the landlord but the tenant becomes an argument as in

(7) Mary's flat is huge and her rent is reasonable.

The frame corresponding to the shifted concept is given in Fig. 11.10. This frame is the frame of a functional concept as the flat is functionally dependent on the tenant,

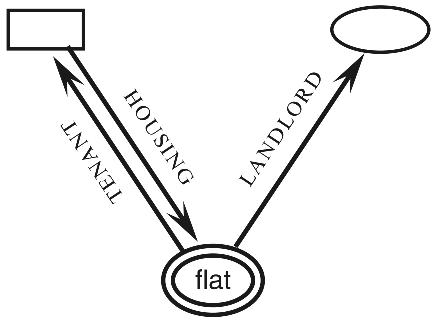


Fig. 11.10 'Flat' as a functional concept

if we assume that each person rents only a single flat. The information expressed by the frame in logical notation is

$$\lambda y.\ \iota u.\ (u = \textsc{housing}(y) \wedge \mathsf{person}(y) \wedge$$
$$\mathsf{flat}(u) \wedge \mathsf{person}(\textsc{landlord}(u)) \wedge y = \textsc{tenant}(\textsc{housing}(y)))$$

The example shows that a shift need not be unambiguous. Concepts can have several attributes in the lexicon allowing for shifts and each might be the one the shift goes to. Disambiguation has to be provided by context.

Although shifts occur frequently, not all attributes can yield a relation for a shift. For example, qualities such as weight or color are not fit for shifting a sortal concept to a relational one. More generally, only *reference-shifting attributes* (cf. Petersen and Werning 2007) can be used for a shift of the conceptual class, i.e., those attributes whose values can belong to a different entity than their domain.

The context can prohibit a shift, too. Jensen and Vikner (2004, p. 23) discuss the example of the concept 'teacher' in the phrase 'the car's teacher'. 'Teacher' is analyzed as having one agentive role, i.e., the teacher teaches someone. This someone has to be animate. Since a car is not animate, it cannot be taught by the teacher. This rules out both a relational interpretation and a weakly relational interpretation of 'teacher' in the phrase. In fact, Vikner and Jensen come to the conclusion that 'the car's teacher' cannot be interpreted semantically at all. The interpretation has to be provided by context which will have to yield a framework to counteract the exclusion of one of the candidates for a relation, e.g., by making the car animate.

Linguistic evidence for the existence of the concept classes and of class shifts is discussed in Löbner (this volume) and especially in Ortmann (this volume). Concerning uniqueness, languages like Ripuarian, Dutch and Fering feature a weak and a strong definite article. The weak definite article is used with a [+U] noun, the strong definite article is used when the noun is lexicalized as a [−U] noun but used as a [+U] noun. Thus, the strong article indicates a class shift. Swedish makes the same distinction but uses a suffix instead of the weak definite article. Concerning relationality, some languages use relativizing or derelativizing morphemes in order to shift nouns from [−R] to [+R] or vice versa. For example, languages like Lakhota or Yucatec shift [−R] nouns to [+R] nouns before they use them in genitive constructions. In contrast, in Mam relational nouns have to be derelativized before they can be used in a construction for a nonrelational noun. Koyukon uses the same morpheme, $k'e$, for both purposes.

11.2.5 Concept Composition

Löbner (2011) argues for composition rules for the combination of relational nouns with a possessor of each of the four concept classes. In genitive constructions, the concept class of the resulting concept is determined by the concept classes of the possessor and possessum. He calls such a construction a 'possessive chain' and defines it as follows: 'A "possessive chain" consists of a head (denoting the possessum), a possessor specification, and possibly recursively embedded further possessor specifications' (Löbner 2011, p. 16). A possessive chain is *maximal* if it is not a proper part of another possessive chain. Maximal possessive chains, Löbner argues, are always [−R], as 'referential maximal NPs carry absolute determination' (Löbner 2011, p. 15). For example, 'father of a friend' is not a maximal chain, '*a* father of a friend' is a maximal chain. *Initial* possessive chains are those that are a proper part of a possessive chain.

Löbner (2011, p. 17) summarizes the composition rules as follows:

> For any possessive chain, initial or maximal,
>
> (i) the total [R] value is the minimum of the [R] values of the members of the chain, where initial chains are [+R] and maximal chains are [−R];
> (ii) the total [U] value is the minimum of the [U] values of the members of the chain.

In other words, if the possessum is proper relational, i.e., a [−U] and [+R] concept, we get a resulting [−U] concept and the resulting concept inherits the relational status of the possessor. For example, 'cake of a friend' is sortal, as 'friend' is proper relational and 'cake' is sortal, i.e. in particular a [−R] concept. For a possessum that is inherently unique, like 'father', the concept class of the genitive construction loses its uniqueness, i.e., 'friend's father' is a [−U] concept (but still relational).

If the possessum is functional, the concept that results from the genitive construction is of the same concept class as the possessor. For example, 'mother's cake' is sortal while 'mother's father' is functional. Table 11.2 gives an overview over all possible combinations (compare Table A1 in Löbner (2011)). We use the symbol $\overset{\text{POSS}}{\sqcup}$ as an abstract symbol for the formation of possessive chains.

Table 11.3 summarizes the logical analyses of all eight cases from Table 11.2.

Table 11.2 Löbner's composition hypothesis

RC	$\overset{\text{POSS}}{\sqcup}$	SC	$\mapsto$	SC	sibling OF judge (sibling of a judge)
RC	$\overset{\text{POSS}}{\sqcup}$	IC	$\mapsto$	SC	sibling OF Mary (sibling of Mary)
RC	$\overset{\text{POSS}}{\sqcup}$	RC	$\mapsto$	RC	sibling OF friend (sibling of a friend [of somebody])
RC	$\overset{\text{POSS}}{\sqcup}$	FC	$\mapsto$	RC	sibling OF spouse (sibling of the spouse [of somebody])
FC	$\overset{\text{POSS}}{\sqcup}$	SC	$\mapsto$	SC	mother OF judge (mother of a judge)
FC	$\overset{\text{POSS}}{\sqcup}$	IC	$\mapsto$	IC	mother OF Mary (mother of Mary)
FC	$\overset{\text{POSS}}{\sqcup}$	RC	$\mapsto$	RC	mother OF friend (mother of a friend [of somebody])
FC	$\overset{\text{POSS}}{\sqcup}$	FC	$\mapsto$	FC	mother OF spouse (mother of the spouse [of somebody])

Table 11.3 Logical analysis of composition in possessive constructions (ε is short for $\lambda Q.\ \varepsilon u.\ Q(u)$)

RC(ε(SC))$\mapsto$ SC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda r.\ P(r) \mapsto \lambda x.\ R(x, \varepsilon u.\ P(u))$
RC(IC)$\mapsto$ SC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \iota u.\ P(u) \mapsto \lambda x.\ R(x, \iota u.\ P(u))$
RC $\circ$($\varepsilon\circ$ RC)$\mapsto$ RC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda y' \lambda x'.\ S(x',y') \mapsto \lambda y' \lambda x.\ R(x, \varepsilon u.\ S(u,y'))$
RC $\circ$ FC$\mapsto$ RC	$\lambda y \lambda x.\ R(x,y) \overset{\text{POSS}}{\sqcup} \lambda y'.\ g(y') \mapsto \lambda y' \lambda x.\ R(x, g(y'))$
Pred(FC)(ε(SC))$\mapsto$ SC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda r.\ P(r) \mapsto \lambda x.\ x = f(\varepsilon u.\ P(u))$
FC(IC)$\mapsto$ IC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \iota u.\ P(u) \mapsto \iota v.\ v = f(\iota u.\ P(u))$
Pred(FC) $\circ$($\varepsilon\circ$ RC)$\mapsto$ RC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda y' \lambda x'.\ S(x',y') \mapsto \lambda y' \lambda x.\ x = f(\varepsilon u.\ S(u,y'))$
FC $\circ$ FC$\mapsto$ FC	$\lambda y.\ f(y) \overset{\text{POSS}}{\sqcup} \lambda y'.\ g(y') \mapsto \lambda y'.\ f(g(y'))$

11.3 Genitive Constructions

In this section, we model two analyses of genitive constructions: the argument-only analysis and the modifier-only analysis. Although both can be modeled in frames, it turns out that relational nouns can be best analyzed as part of an argument construction while pure sortal nouns are amenable to a modifier construction. Thus, frames favor the split approach.

11.3.1 Genitives as Arguments

Seeing genitive constructions as argument constructions means, in terms of frames, that the genitive fills an attribute value of the head noun's frame. Thus, the argument construction is modeled straightforwardly in case there already is an attribute of the right type in the frame. This is the case for relational nouns and – to some extent – for weakly relational sortal nouns.

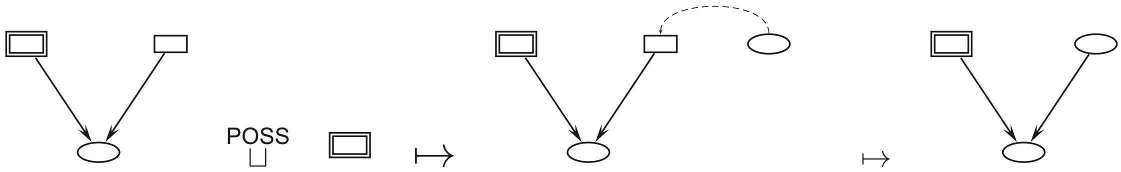


Fig. 11.11 Composition of an RC and an SC yields an SC

11.3.1.1 The Case of Relational Nouns

In the case of a relational noun, constructions with genitives in the argument position can be modeled straightforwardly. For example, the phrase 'sibling of a judge' involves a relational noun plus a sortal noun. Here, 'judge' specifies the argument of the relational noun.

In terms of frames, saturating the possessor argument of a relational concept is analyzed as unifying the argument node of the relational frame with the central node of the possessor frame. To unify the nodes, the central node's reference has to be uniquely determined. In the cases where the concept is [−U], an (otherwise unspecific) object falling under the concept is chosen. This step of losing the argument property is overtly realized in of-constructions in English: the possessor noun has to be accompanied by a determiner in constructions of this type; hence we get 'sibling of *a* judge' instead of 'sibling of judge'. As none of the other frame nodes is affected by this form of composition, it follows from the considerations about frame graphs of different concept classes in Sect. 11.2 that the composed frames correspond to the concept classes Löbner predicts. Table 11.4 summarizes all eight cases of frame composition in argument constructions.

We discuss two examples in detail. In Fig. 11.11, a default frame for an RC is composed with a default frame for an SC. In logical notation, this is of the form $\lambda y \lambda x.\ \mathrm{R}(x, y)$ applied to a representative of the SC $\lambda r.\ \mathsf{P}(r)$.[9] The choice of an arbitrary representative of the SC is done by the ε-operator, which is similar to Partee's iota operator (Partee 1986) with the difference that is does not require uniqueness of the chosen object. Hence the resulting expression is of the form $\varepsilon u.\ \mathsf{P}(u)$ instead of $\iota u.\ \mathsf{P}(u)$. In short, we want to calculate $\varepsilon(\mathrm{SC})$, where ε stands for $\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)$:

$$\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)(\lambda r.\ \mathsf{P}(r)).$$

By β-reduction, we get

$$\varepsilon u.\ \lambda r.\ \mathsf{P}(r)(u).$$

[9]We write predicates in the same fonts as in frames, i.e. A for an attribute and T for a type.

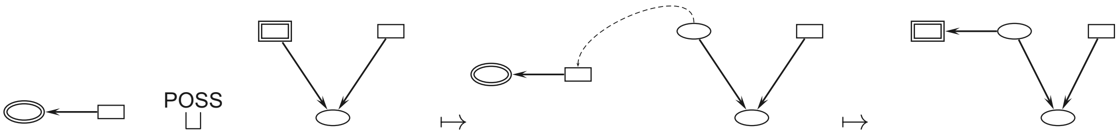


Fig. 11.12 Composition of an FC and an RC yields an RC

Another β-reduction yields

$$\varepsilon u.\ \mathsf{P}(u).$$

By functional application of the RC to the choice for the SC, short RC(ε(SC)), we get

$$\lambda y \lambda x.\ \mathrm{R}(x, y)(\varepsilon u.\ \mathsf{P}(u)).$$

By β-reduction, we get

$$\lambda x.\ \mathrm{R}(x, \varepsilon u.\ \mathsf{P}(u)),$$

which denotes an SC, as Löbner predicts. The resulting expression corresponds to the logical interpretation of the resulting frame in Fig. 11.11. Functional application of the RC to the representative for the SC (chosen by the choice function) corresponds to unification of nodes in frames.

The second example is the composition of an FC with an RC. The procedure is similar (Fig. 11.12): a representative for the RC is chosen, so the central node of the RC is uniquely determined. This node is unified with the open argument node of the FC. The resulting frame has the central node of the FC and the open argument of the RC. Since there was no path from the open argument node in the RC to its central node, and this is the only connection between the two parts of the frame, there is no path from the open argument node to the central node in the new frame. Thereby, the central node is open. Thus, the resulting frame represents an RC.

In λ-notation, we have that an FC of the form $\lambda y \lambda x.\ x = f(y)$ is composed with an RC of the form $\lambda y' \lambda x'.\ \mathrm{S}(x', y')$. Note that the FC is seen as predicative here.[10] In order to unify the possessor argument of the FC with the possessum argument of the RC, we again choose one arbitrary representative of the RC; i.e. $\varepsilon \circ$ RC:

$$\lambda y' (\lambda \mathsf{Q}.\ \varepsilon u.\ \mathsf{Q}(u)(\lambda x'.\ \mathrm{S}(x', y'))).$$

[10]This is an artefact of the λ-notation. In the graph notation, the central node is closed iff it is determined by an incoming arc from another open node or from context. If a construction fills that node or destroys the connection to the open node, the central node is open. In λ-notation, there is no such straightforward constraint.

By β-reduction we get

$$\lambda y'(\varepsilon u.\ \lambda x'.\ \mathrm{S}(x', y')(u)).$$

Another β-reduction yields

$$\lambda y'.\ \varepsilon u.\ \mathrm{S}(u, y').$$

Now we can compose the predicative FC with the result[11] Pred (FC)$\circ$($\varepsilon\circ$ RC):

$$(\lambda y \lambda x.\ x = f(y)) \circ (\lambda y'.\varepsilon u.\ \mathrm{S}(u, y'))$$

which yields

$$\lambda y'(\lambda y \lambda x.\ x = f(y)(\varepsilon u.\ \mathrm{S}(u, y'))).$$

By β-reduction, we get

$$\lambda y' \lambda x.\ x = f(\varepsilon u.\ \mathrm{S}(u, y')).$$

Since the variable x in the formula is not uniquely determined by the variable y', we have a proper relational concept, as the composition rules predict.

The examples show that constructions with relational nouns and genitives in argument positions can be straightforwardly modeled in frames. In Table 11.4, a summary of all possible combinations with relational nouns in genitive constructions plus their associated λ-expressions are given.

11.3.1.2 The Case of Weakly Relational Sortal Nouns

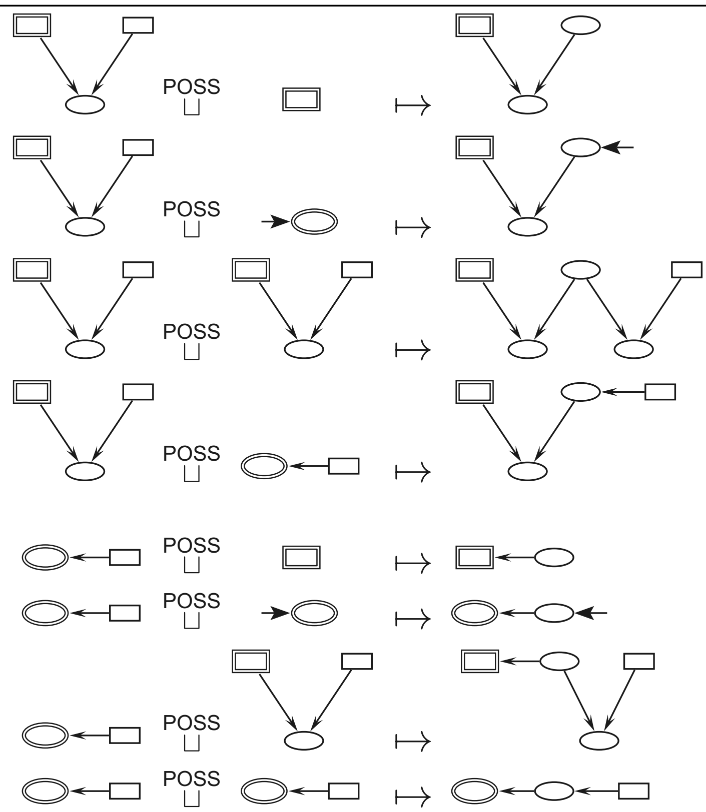
For relational nouns, the argument construction is straightforward. For sortal nouns, it is less so, but there is a subclass of sortal nouns that facilitate an argument construction, i.e., the weakly relational sortal nouns. As introduced in Sect. 11.1, weakly relational sortal nouns are those that have a relation established in the lexicon that can be used in an argument construction although it is not obligatory.

What happens in the argument construction is that a weakly relational sortal noun is *shifted* to a relational noun, using the relation given in the lexicon. Then, the argument construction proceeds as for relational nouns.

[11] We write Pred (FC) to denote the predicative reading of the FC.

Table 11.4 Frame composition in possessive constructions

$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{SC} \mapsto \mathrm{SC}$
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{IC} \mapsto \mathrm{SC}$
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$
$\mathrm{RC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{FC} \mapsto \mathrm{RC}$
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{SC} \mapsto \mathrm{SC}$
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{IC} \mapsto \mathrm{IC}$
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{RC} \mapsto \mathrm{RC}$
$\mathrm{FC} \overset{\mathrm{POSS}}{\sqcup} \mathrm{FC} \mapsto \mathrm{FC}$



11.3.1.3 The Case of Pure Sortal Nouns

So far, we have discussed argument constructions with relational concepts and with weakly relational sortal concepts, i.e., with those kinds of concepts that come with a relation that can be used in the genitive construction. Let us now regard the third kind of nouns in argument constructions: pure sortal nouns are those that cannot be shifted for semantic reasons, thus in the notation of Löbner (2011) they can just be shifted by level-2 shifts, i.e., shifts that are fully dependent on the given context of utterance.

To establish a relation for the argument construction, a new attribute has to be added to the possessum frame. By default, this is a possessor relation; any more specific relation that context provides can overrule the default. With the new relation added, the possessum frame is shifted from an SC to an RC, using the new attribute (see Fig. 11.13 for an example of such a shifted concept). Even stronger shifts can be necessary to stick with the argument-only analysis, i.e., shifts that do not introduce just one more attribute into the frame but a more complex structure. Accepting such strong shifts which involve the addition of a new attribute is necessary in order to support the argument-only thesis of genitive constructions in a frame-based analysis.

Fig. 11.13 ‘stone’ as a relational concept

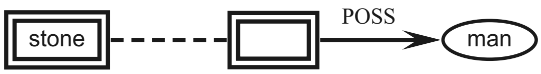


Fig. 11.14 The genitive-as-modifier construction for ‘stone of a man’

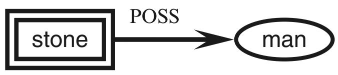


Fig. 11.15 The frame for ‘stone of a man’

11.3.2 Genitives as Modifiers

If genitive constructions are seen as modifier constructions, the genitive structure is brought along by the genitive marker itself. Under this analysis, ‘stone of a man’ is interpreted by first constructing the frame for ‘of a man’ which we call a *genitive frame*, and then connecting that frame to the ‘stone’ frame. Which relation gets chosen for the connection depends on the concepts involved. The default is an attribute for possession or control which we will call POSS in the following. The constraint on this is that the relation has to match the types of the nodes to be connected.

Löbner (p.c.) proposes a *minimality maxim* that demands that as much information as possible should be integrated, i.e., the genitive frame should be merged with a suitable substructure of the frame whenever possible.

As for the argument interpretation of genitive constructions, we distinguish three cases: genitives with pure sortal concepts, with weakly relational sortal concepts and with relational concepts. In the following, we will discuss each of these cases separately.

11.3.2.1 The Case of Pure Sortal Nouns

In the case of pure sortal concepts, the genitive construction adds the genitive frame to the possessum frame. By default, the relation is specified as possession, but it can be overruled by any relation that the context may provide.

For example, take the phrase ‘stone of a man’. The genitive construction is shown in Fig. 11.14. ‘Stone’ does not have any inherent relation that is fit for a genitive construction, thus, the attribute is specified by default as possession. The resulting frame is shown in Fig. 11.15. In case there is another relation suggested by context, that relation overrides the default. For example, if it is the stone the man has painted, the relation is specified by an attribute like PAINTER.

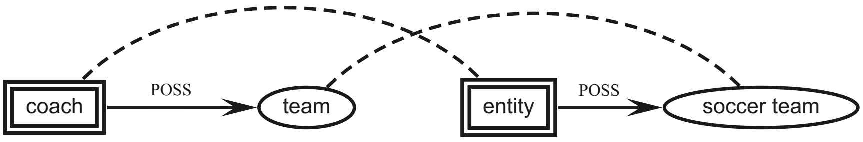
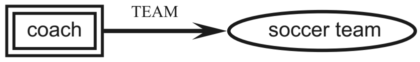


Fig. 11.16 The genitive-as-modifier construction for ‘coach of a soccer team’

Fig. 11.17 The frame for ‘coach of a soccer team’



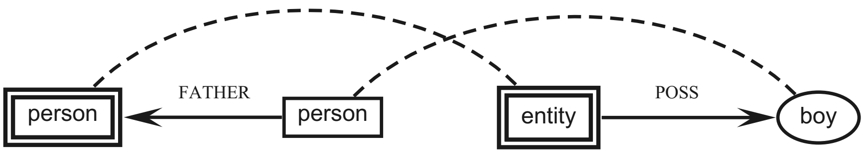


Fig. 11.18 The genitive-as-modifier construction for ‘father of a boy’

11.3.2.2 The Case of Weakly Relational Sortal Nouns

For weakly relational sortal concepts, the genitive construction starts in the same way as for pure sortal concepts: the genitive frame is introduced and connected with the possessum frame. The difference lies in the specification of the relation. Here, we have a suitable relation available, i.e., one that can connect possessum and possessor without a clash of types. Thus, following the minimality maxim, the genitive frame is merged with the given relation and its value.

For example, take the phrase ‘coach of a soccer team’. The genitive construction is shown in Fig. 11.16. As we see, the types of the respective nodes match, i.e., ‘coach’ is a subtype of ‘entity’ and ‘soccer team’ is a subtype of ‘team’. Thus, the frames can be merged along the TEAM attribute. The POSS attribute is overruled. The resulting frame is depicted in Fig. 11.17.

11.3.2.3 The Case of Relational Nouns

The case of a relational concept is similar to that of weakly relational sortal concepts. First the genitive frame is connected to the possessum frame and then, to avoid unnecessary information, the genitive frame is merged with a suitable relation that is already in the possessum frame. The only difference lies in the status of the possessum node. In the frame for a relational concept, this is an open argument. Thus, an extra step has to be taken, i.e., closing the argument.

For example, take the phrase ‘father of a boy’. The genitive frame is shown in Fig. 11.18. As ‘father’ is a subtype of ‘entity’ and ‘boy’ is a subtype of ‘person’, the respective nodes can be unified. The POSS relation gets overruled by the FATHER relation. The open argument of the ‘father’ frame is closed. Figure 11.19 shows the resulting frame.

Fig. 11.19 The frame for 'father of a boy'

Fig. 11.20 Another frame for 'father'

Fig. 11.21 The genitive-as-modifier construction for 'father of a boy', merging with the node for the offspring

Fig. 11.22 The genitive-as-modifier construction for 'father of a boy', merging with the node for the ancestor

This example can be taken to point out a difficulty with the modifier construction. As a father is a person, he has a father himself. Thus, the frame in Fig. 11.20 is a frame of 'father', too. Now, when the genitive frame is added, there are two possible results, as in Figs. 11.21 and 11.22. Prima facie, there is no reason why the interpretation in Fig. 11.21 should be favored – on the contrary, in the frame in Fig. 11.22, both of the following constraints are fulfilled. The direction of the POSS relation is preserved by the relation that overrides it, and it does not have to change the argument status of the merged node.

We do not claim that this difficulty cannot be overcome[12]; it just shows that the modifier approach is not straightforward to model in the case of relational nouns, and, as similar phenomena can occur there, in the case of weakly relational sortal nouns.

Another approach to the modifier construction lies in using frames less restrictively. So far, we have regarded frames for concepts, not frames for grammatical constructions. Using these, the modifier account can be made more uniformly. For example, Löbner (p.c.) proposes an analysis in which the genitive construction is facilitated by an extra frame for the relation between possessor and possessum. E.g., a frame for 'control' has one attribute for the controller and one for the entity controlled. Unifying the values with the central nodes of the respective frames yields

[12]For example, it can be argued that the genitive construction should be made with a minimal frame for the concept, like the one in Fig. 11.18. This, in turn, opens the question about definition and existence of minimal frames.

a frame for the genitive construction that explicitly models the control relation. A frame for the concept 'man's stone' would thus start with a control frame and have the frame for 'man' and 'stone' inserted such that the central node of the new frame is the node of type stone.

11.4 Discussion

In our paper, we have shown how concept composition is modeled in terms of frames, regarding the special case of genitive constructions. As frames are proposed to be cognitively adequate, our frame results speak in favor of the split approach. Genitive constructions with relational and weakly relational sortal nouns are best interpreted as argument constructions while genitive constructions with pure sortal nouns are most naturally interpreted as modifier constructions.

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