# Chapter 1
# General Introduction

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The topic of this volume is the investigation of frame representations and their relations to concept types. Frames are cognitively founded and formally explored devices for representing knowledge about objects and categories by means of attributes and their values. They offer a flexible and expressive way of representing concepts of different types in language, philosophy and science at different levels of detail and at different stages of processing and development. This interdisciplinary volume presents approaches to frames and concept types from the perspective of linguistics and philosophy of science.

## 1.1 Frames and Concept Types in Language and Science

Inspired by the work of F. C. Bartlett, Marvin Minsky and others, frames have drawn considerable interest in the 1970s and 1980s as a common model across disciplines for representing semantic and conceptual knowledge. The collection on "Frames, Fields, and Contrasts" edited by Lehrer and Kittay (1992) provides a good overview on the state-of-the-art of that time. Notably, this collection includes articles by scholars such as Lawrence Barsalou, Charles Fillmore and Ray Jackendoff, among others. These interdisciplinary efforts have since then been abandoned to a certain extent in favor of more specialized investigations within the different scientific disciplines. For example, frame theory is the basis of most of the specification languages for ontology building used in the context of the semantic web. These languages draw on logics (e.g. Description Logics, Sorted Feature Logic) that grew

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out of knowledge representation languages (e.g. KL-ONE) originally developed to formalize frame representations. In computational linguistics, frames appear as feature structures in unification-based grammar formalisms such as Lexical Functional Grammar (Bresnan 2001) and Head-Driven Phrase Structure Grammar (Pollard and Sag 1994). In linguistic semantics, Fillmore has put his frame semantics program into practice with the FrameNet project (Fillmore et al. 2003; Fillmore and Baker 2010), which, however, only employs flat, non-recursive frame structures in its current implementation. It is a central goal of the present collection to revive the interdisciplinary investigation of concepts and frames and to emphasize the potential richness of frame representations, which has been restricted in the more specialized developments due to technical and practical considerations.

### *1.1.1 Types and Goals of Frame Representations*

In his extensive compendium on frame semantics, Busse (2012, p. 550ff) draws a distinction between *predicative frames* and *concept frames*. Predicative frames are understood as frame structures whose primary purpose is the representation of events and states of affairs in terms of their situation types and the participants involved. Fillmore's (1982) frame-semantic approach and its manifestation in the FrameNet project is considered as a prototypical example for the use of predicative frames, since, according to Busse, the main purpose of semantic frames in FrameNet lies in the description of *semantic valency*. This view is in line with the characterization given by Fillmore (2007, p. 129), who describes the FrameNet project as being "dedicated to producing valency descriptions of frame-bearing lexical units, in both semantic and syntactic terms" (see also Osswald and Van Valin, this volume). Consider the classical example sentence in (1):

(1) *Brutus stabbed Caesar in the back with a knife*.

Within FrameNet, situations of the type described by (1) are represented by means of the frame Cause_harm, which comes with the semantic roles (or 'frame elements') Agent, Victim, Body_part, and Instrument, among others. The basic idea is that the main verb of (1) evokes the frame Cause_harm and that the remaining constituents are realizations of (some of) the semantic roles associated with the frame, as indicated in Fig. 1.1.[1]

[1]The analysis is based on the FrameNet online database as of January 2013. While (1) is not an actual corpus example of FrameNet, there are analogous examples in the database such as *Unemployed Martin Lewis of Trinity Close in the town, stabbed Trevor Lampett in the chest with a 10 inch kitchen knife.*

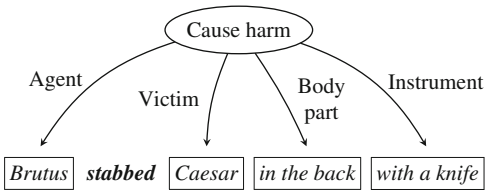


**Fig. 1.1** Frame analysis of (1) along the lines of FrameNet

Viewing frames of this type as 'predicative' emphasizes the fact that the root node of the frame is associated with the central predicate of the represented expression, while the arguments of the predicate are bound by the semantic roles of the frame.[2]

The given frame-semantic representation resembles to a certain extent the basic scheme of Neo-Davidsonian approaches to event semantics, with the label of the root node taken as a one-place predicate of events and the semantic roles as two-place predicates relating events to participants (cf. Parsons 1990, 1995). A straightforward translation of Fig. 1.1 along these lines would give rise to a formula like (2).

(2) $\exists e(\text{Cause\_harm}(e) \wedge \text{Agent}(e, \text{Brutus}) \wedge \text{Victim}(e, \text{Caesar}) \wedge \text{Body\_part}(e, \text{back}) \wedge \text{Instrument}(e, \text{knife}))$

There are several issues with this representation. For one thing, the formula shows the coarse-grained sortal characterization of event types in FrameNet. The fact that the described event is a stabbing event is not captured at all. This deficiency could simply be remedied by specializing the event predicate 'Cause_harm' to 'Stabbing'. Another, more problematic aspect is the role predicate 'Body_part'. It seems odd at best to regard the back of Caesar as the body part of the stabbing event. The back in question is rather a body part of Caesar. In fact, the informal definition of the 'Cause_harm' frame in FrameNet correctly speaks about "the body part of the victim". The problematic representation in (2) is thus a mere consequence of the Procrustean implementation of frames in FrameNet. A more appropriate frame representation would include a characterization of the body part as a mereological part of the victim, and it would furthermore represent the resulting location of the instrument expressed by the preposition *in*, which is also missing in (2).

While the focus of predicative frames is on binding together the participants of states of affairs, concept frames are primarily concerned with representing the attributes and properties of an entity. Frame structures of this type are closely related to the modeling of categories and they are mostly expressed by nominal expressions (Busse, *ibid.*). For instance, the concept frame for *bottle* comes with attributes such as WEIGHT, VOLUME, and PURPOSE (see Fig. 1.4 below). Concept frames are fully compatible with Barsalou's (1992) proposal, who regards frames as a general format for the representation of categories. Frames in the sense of Barsalou are recursive

[2]For the moment, we put aside the distinction between the formal arguments of a predicate and the syntactic arguments and adjuncts of a verb. FrameNet draws a distinction between "core" and "non-core" roles in order to single out the roles that contribute to the core meaning of the frame.

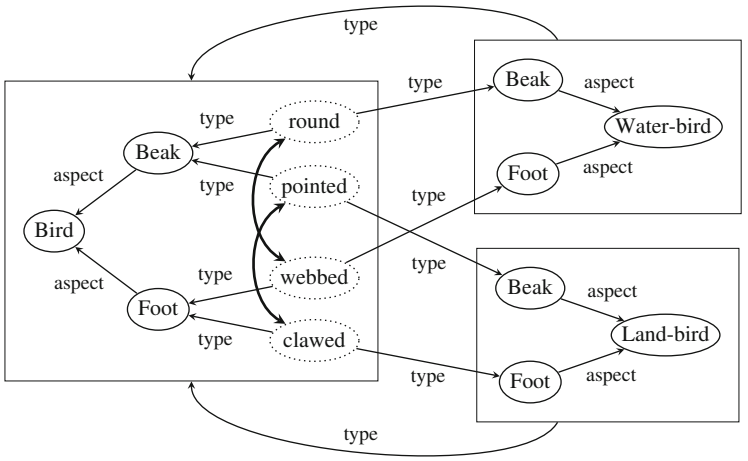


**Fig. 1.2** Frame representation of Ray's taxonomy after Chen (2002) in the guise of Barsalou (1992)

attribute-value structures with structural invariants and constraints. They have been introduced as extensions of simple feature list representations in order to overcome the limitations of the latter. As emphasized by Barsalou and Hale (1993), the move from feature lists to frame structures is orthogonal to extensions of feature list models such as prototype theory (cf., e.g., Rosch and Mervis 1975), which tries to take into account the observation that certain objects of a category are more representative of the category than others. The same can be said of the relation between concept frames and Gärdenfors' (2000) conceptual space approach. The main advantage of switching from feature lists to frames is the representation of structural information and structural constraints. The addition of recursion and constraints does not prevent us, in principle, from introducing weighted attributes, similarity measures on values, and the like. But it seems fair to say that it is still an open issue how to reconcile structure and compositionality with gradual membership and family resemblance – a question to which neither prototype theory nor the theory of conceptual spaces has provided a fully satisfying answer so far (pace Kamp and Partee 1995; see also Gleitman et al. 2012).

Inspired by the work of Barsalou, frames have been adopted for the modeling of concepts in various domains. A particularly interesting case is the modeling of conceptual changes in science as elaborated, for instance, by Andersen et al. (2006); see also Part B of the present volume. The following example from Chen (2002) is concerned with the development of avian taxonomy from the seventeenth century onwards. Figure 1.2 shows a partial frame representation of the concept of 'bird' and its subdivision into water birds and land birds based on the taxonomy proposed by John Ray in 1678. The representation follows closely the original notation of Barsalou (1992, p. 52) for representing taxonomies, not the slightly simplified variant given in Chen (2002, p. 5); see Zenker (this volume) for the latter version.

In Barsalou's graphical notation, attributes are treated as *aspects* of concepts while attribute values are characterized as *types* of attributes. The subordination relation between the bird concept and its sub-concepts is explicitly represented by the 'type' relation. The double-headed arrows indicate co-occurrence relations between attribute values.

The basic observation that underlies Ray's taxonomy is that birds fall into two distinct classes and that the membership in these classes is determined by a combination of beak type and foot type: Birds with round beak and webbed feet are water birds and birds with pointed beak and clawed feet are land birds. The co-occurrence relations imply an incompatibility of round beak and clawed feet, and of pointed beak and webbed feet. Chen shows how Ray's taxonomy underwent several changes due to new empirical findings, and he argues that these revisions of the scientific concept of bird and its subordinate concepts can be nicely explained with reference to changes in the respective frame representations (cf. Zenker, this volume). For instance, the discovery of a new type of bird in South America which has webbed feet and a pointed beak revealed that one of the assumed co-occurrence relations had been invalid. As a consequence, the taxonomy was revised and refined by taking into account additional morphological features of birds. The advent of Darwin's theory of evolution led eventually to a further, more drastic revision of the classification system in putting more emphasis on genealogically relevant anatomical features. By making explicit in this way the role of the attributes involved in establishing and changing scientific concepts, frames have proven to be a useful tool for philosophers of science.

It is illustrative to compare the frame representation of Fig. 1.2, which follows the notational conventions of Barsalou (1992), with an equivalent attribute-value representation along the lines of the formalisms employed for unification-based grammars such as HPSG (Pollard and Sag 1994) and for the representation of linguistic data in general (cf. Osswald 2012). In contrast to Barsalou's inspiring but informal synopsis, these formalisms build on elaborate mathematical and logical foundations (cf. Carpenter 1992; Rounds 1997). Figure 1.3 sketches how the frame information expressed in Fig. 1.2 can be formally described in terms of type declarations. Such declarations specify which types subsume which others, which attributes are appropriate for structures of a given type, and which values are admissible for a given attribute. In addition, more complex implicational attribute-value constraints can be defined. As specified in the figure, the type 'bird' comes with the attributes BEAK and FOOT, for which values of type 'beak' and 'foot' are admissible, respectively. (Note that these value restrictions simply express that the beak of a bird is a beak and that the foot of a bird is a foot; cf. Sect. 1.1.2 on the dual interpretation of attributes as types.) The two trees in the upper line of the figure indicate that the type 'beak' has the subtypes 'round' and 'pointed' and the type 'foot' has the subtypes 'webbed' and 'clawed'. Together with the two bi-implicational constraints, the given declarations induce the taxonomy shown in the upper right of the figure, with the newly introduced types 'water-bird' and 'land-bird'. Figure 1.3 also gives graph representations of the three bird frames with attributes depicted not as nodes as in Fig. 1.2 but as arcs, which is the standard representation throughout this

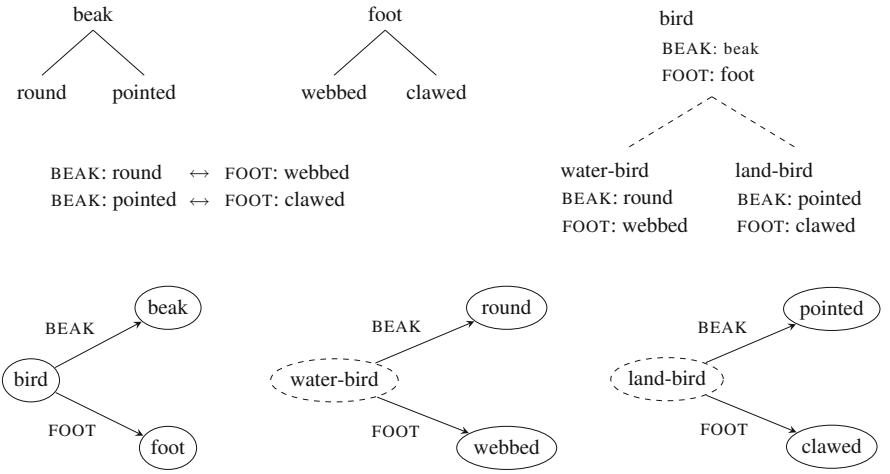


**Fig. 1.3** Type declarations, co-occurrence restrictions, and induced inheritance hierarchy

volume. At closer inspection, the type declarations reveal some deficiencies of the original frame representation since, strictly speaking, 'round' and 'pointed' are better seen as values of an attribute FORM associated with 'beak', than as subtypes of 'beak'. A similar argument applies to 'webbed' and 'clawed'.

Let us return to the distinction of different kinds of frames introduced at the beginning of this section. Predicative frames have been loosely associated with verbs, and concept frames were said to be expressed mainly by nouns. However, it should be kept in mind that the linguistic categories 'verb' and 'noun' play only a secondary role in this distinction. Verbs can easily be nominalized and the FrameNet frame sketched in Fig. 1.1 would apply to the nominal expression *the stabbing of Caesar by Brutus* as well. The crucial point of the proposed distinction seems rather to be the representation of inherent attributes in concept frames and the resulting fine discrimination between related concepts. For instance, the fact that bottles have a neck and a body and are typically used as containers for liquids sets them off from other kinds of containers such as baskets, bowls, and boxes. Predicative frames of the type employed in FrameNet, on the other hand, do not allow for such a fine discrimination. The expression *Brutus smacked Caesar on the back with his hand* would get the same frame analysis as (1) as far as the specific activity is concerned. Simply introducing specific event types such as 'stabbing' and 'smacking' would not resolve the matter since type distinctions have no explanatory value *per se*. In order to explain the differences between stabbings and smackings, one needs to identify the relevant attributes and components of the respective event concepts. For example, differences in the way in which the active participant acts on the affected participant can explain why it makes more sense to say *Brutus smacked Caesar against the wall* than *Brutus stabbed Caesar against the wall*, that is, why a caused motion context is fairly natural for *smack* but much less so for *stab*. Generally speaking, the task in question is similar to componential analysis, a

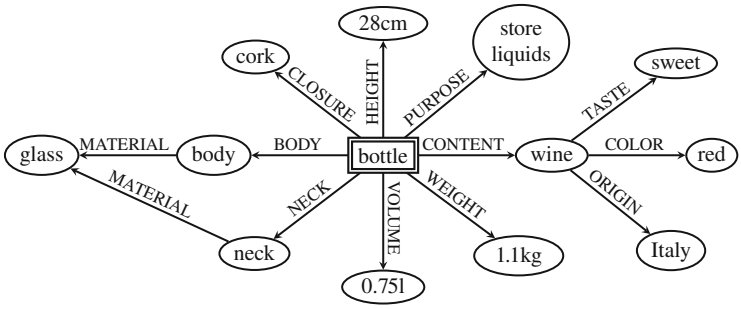


**Fig. 1.4** Simplified frame for *bottle of Italian red wine*

method which, in its basic form, dates back at least to the work of Louis Hjelmslev (cf. Lyons 1977, Chap. 9). Boas (2008) proposes to combine componential analysis with Fillmore's frame semantics. Bergen and Chang (2005), by comparison, aim at a more explicit representation of event-internal components by means of frame-like structures. Similar goals are pursued by Osswald and Van Valin (this volume).

The foregoing discussion shows that the adequate modeling of events and states of affairs by means of frames calls for a combination of predicative frames and concept frames. Participant roles are just one kind of characteristics. The sub-eventual structure matters too, as do manner-related attributes of various sorts. But the synthesis of predicative frames and concept frames is not only relevant to event and situation frames. The binding of participants can be necessary for concept frames as well. For example, the content of a bottle can be regarded as a component of the bottle concept, and on the linguistic level, the content is typically expressed by an *of*-phrase like in *a bottle of wine*. The need for representing arguments within concept frames is even more evident in the case of functional concepts such as 'mother' (cf. Petersen and Osswald, this volume).

### *1.1.2 Types of Frame Attributes*

Frames are descriptions of categories and individual objects in terms of recursive attribute-value structures with the attributes representing the properties which characterize a category or an individual object. Attributes can be conceived as functional relations since they assign unique values to objects. Attribute values are concrete or underspecified specifications which are represented by potentially complex frames themselves. It is this recursive structure that makes frames flexible enough to represent information with any desired level of detail. By way of illustration, consider the concept of a bottle filled with Italian red wine and closed with a cork. A simplified frame of this concept can be depicted by a graph as in Fig. 1.4.

The example in Fig. 1.4 shows that the attributes constituting a frame can be of a diverse nature: First, there are attributes such as VOLUME, HEIGHT and WEIGHT which can be called 'dimensions' since they assign an abstract value to the object. The values of dimensions are abstract in that they are not concrete objects in themselves. Rather, they are properties out of a range of mutually exclusive alternative properties. The part attribute is another type of attribute, which assigns unique parts to the possessor. For a complex object, its composition in terms of constitutive parts is a central aspect of description. Terms for parts figure in mereological frames such as anatomical frames and frames which capture the design of artifacts. The respective attributes take values that are on a par with the whole regarding complexity and concreteness, but they are not independent objects. In the frame of the bottle, attributes of this type are, for example, BODY, NECK and CLOSURE which identify the parts a bottle consists of. A third type of attribute assigns to the referent another independently existing object which is related to the referent in a one-to-one relation. In the bottle frame, the CONTENT attribute is an instance of this type of attribute. The PURPOSE attribute is yet another type of attribute which specifies what is usually done with the referent of the frame. In this case, the value of the PURPOSE attribute states that a bottle is used for storing a liquid. For a discussion of similar distinctions of attribute types see Guarino (2009).

Since frames are recursive structures, attribute values are frames themselves and can be specified further by attributes. The value of an attribute like CONTENT, for example, may itself be a complex attribute-value structure. This is the case with a value like 'wine', which is characterized by attributes such as TASTE, COLOR and ORIGIN. The expressiveness of frames does not only result from their recursive structure but also from their potential to reveal shared structures. For instance, the attributes BODY and NECK both exhibit the attribute MATERIAL with a value 'glass.' The fact that the body and the neck of the bottle are made of the same material is expressed in the frame graph by the two MATERIAL-arcs pointing to the same node.

The expressiveness of frames which results from the possibility to express recursive structures, to address substructures by attribute paths, and to flexibly add additional attribute-value specifications, is considered to be one of their main advantages over pure logical formalisms based on First Order Logic. However, frames share with these formalisms some problems already discussed in Woods (1975). Woods devotes his well-known "What's in a link" article to the discussion of common inappropriate uses of semantic networks, i.e. attribute-value formalisms, and the question of the minimal requirements an appropriate frame attribute (or 'link' in his terminology) has to fulfill. He illustrates the problem of allowing attributes to be unrestricted arbitrary binary relations by the frame-like structure shown in Fig. 1.5. Although *height* and *hit* can be logically represented by two-place predicates, the ontological status of the link established between John and 6 ft and between John and Mary differs fundamentally. The expression 6 ft specifies a value along the HEIGHT dimension of John while HIT refers to a hitting event which establishes its own event frame along the lines of the one depicted in Fig. 1.1. From

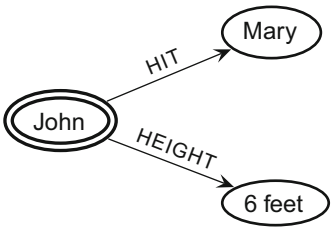


**Fig. 1.5** Frame containing different types of relations (Woods 1975, p. 54)

Woods' remarks one can extract a linguistic test to identify attributes (ibd., p. 53): Y is a value of the attribute A of X if we can say that *Y is the A of X*. While it is appropriate to say that 6 ft is the height of John, one cannot say that Mary is the hit of John. Rather Mary is the patient or victim in a hitting event of which John is the agent. The strategy to implement Woods' test pursued within this volume is to require attributes to express many-to-one, i.e. functional, relations which are usually expressed by nouns. In natural language, attributes correspond to functional nouns, which frequently occur in definite and possessive contexts: *Y is* ***the*** *A* ***of*** *X* (see Sect. 1.1.3).

A second problem is that frame-based formalisms usually force a radical choice between attributes and types as both sets are considered to be disjoint and formally unrelated. One consequence of this choice is that it is common that the same label is used in frame representations to address a type and an attribute (e.g., label 'neck' in Fig. 1.4 or label 'beak' in Fig. 1.3). Naturally, our intention while constructing the bottle-frame in Fig. 1.4 was to express that the neck of the bottle is a neck. However by using the label 'neck' once for the attribute NECK and once for the type 'neck', we have formally created two descriptional primitives which would be unrelated to each other in most frame languages. Guarino (1992) accounts for the systematic relationship between such an attribute and its corresponding type by distinguishing between the denotational and the relational interpretations of concepts that express binary relations. While the relational interpretation refers to the expressed relation itself (that is in the case of 'neck' the binary relation between things and their necks), the denotational interpretation refers to the range of such a relation (that is the set of all necks). Presupposing that attributes are labeled by functional concepts, Petersen (2007) develops a frame account in which there exists for each attribute a unique type corresponding to the value range of the attribute function. As attributes can be identified by their range types, it is from a formal viewpoint sufficient to consider attributes as special kinds of types that have an additional relational interpretation as a function (cf. Petersen and Gamerschlag, this volume). Thereby, one no longer needs to introduce two distinct primitives for functional concepts like for 'neck' in Fig. 1.4. The ontological commitments behind this modeling convention reflect Barsalou's view on attributes and value types: "Attributes are concepts that represent aspects of a category's members, and values are subordinate concepts of attributes" (Barsalou 1992, p. 43).

**Table 1.1** Four basic concept types

| | Non-unique reference | Unique reference |
|---|---|---|
| Non-relational | Sortal concepts: 'dog', 'house', 'verb' | Individual concepts: 'pope', 'sun', 'Mary' |
| Relational | Proper relational concepts: 'friend', 'son', 'part' | Functional concepts: 'father', 'age', 'meaning' |

### *1.1.3 Concept Types, Attributes, and Functional Nouns*

Frames decompose concepts into attributes, which are functional relations between objects and attribute values. Attributes thus correspond to functional concepts, which are characterized by (i) inherent relationality and (ii) inherent uniqueness, i.e., for each attribute there is exactly one value at a time. Based on the idea that concepts in natural language belong to different basic types, Löbner (2011) proposes the system of four basic concept types (Table 1.1), which results from defining inherent relationality and inherent uniqueness as binary features.

The distinction between non-relational and relational concepts, which was already argued for by Frege (1892) and Behaghel (1923) and later elaborated on by Montague (1970), differentiates sortal concepts such as 'dog' or 'stone' from relational concepts such as 'friend' or 'son' in that the latter require an additional argument for reference. Sortal concepts, named as such by Strawson (1959), classify objects into sorts; relational concepts describe objects in relation to another object. Formally, this distinction corresponds to the differentiation between one-place and two-place predicates (cf. Partee 1986; De Bruin and Scha 1988; Löbner 1985; Barker 1995). Löbner (1985) extends the classical distinction between sortal and relational concepts by the distinction between inherently unique and inherently non-unique reference of concepts. The outcome is the cross-classification of four concept types in Table 1.1, which differ with respect to their referential properties. Like non-unique concepts, i.e. sortal and relational concepts, unique concepts can be differentiated with respect to the number of arguments involved: individual concepts such as 'pope' and 'sun' refer to unique referents without requiring an additional argument, whereas functional concepts such as 'father (of someone)' and 'age (of someone)' depend on an additional argument for identifying a referent. Among the different concept types, functional concepts are of particular interest since they directly correspond to attributes in frames and therefore play a central role not only in linguistics but in conceptual and theoretical evolution in general.

The four-way concept classification can be immediately turned into a noun classification in which each noun is characterized with respect to the concept type it corresponds to. Thus, concepts such as 'pope' and 'father' correspond to individual and functional nouns in natural language. Individual and functional nouns are inherently unique in the sense that the number of possible referents is restricted to one in a given context. By contrast, for sortal nouns such as *dog* and relational nouns such as *friend* the number of possible referents is unrestricted. Relational and functional nouns are inherently relational and require the specification of an

additional argument for reference. As argued by Löbner (2011), the referential properties influence the way nouns are used grammatically: In accordance with their inherent relationality, functional and relational nouns can be regarded as predisposed for a possessive use. Due to their inherent uniqueness, individual and functional nouns exhibit a predisposition for a definite use. Hence, functional nouns which can be considered as double marked with respect to their referential properties, have a predisposition for both definite and possessive use (cf. Horn and Kimm, this volume, for a statistical test of Löbner's hypothesis). However, many nouns are polysemous, thus a noun represents a certain type only with respect to a given lexical reading: *teacher* for example has both a sortal reading (in the sense of a job title) and a relational reading (in the sense of 'teacher of someone').

Each noun type has – according to the referential properties – a predisposition for a certain kind of determination, the so-called "congruent determination" (Löbner 2011, p. 360). Reciprocally, the kinds of determination have input requirements which lead to a predisposition for a certain noun type (Löbner 2011, p. 290). Definite articles for example require inherently unique nouns and inherently unique nouns have a predisposition for definite articles. However, nouns are often used incongruently, i.e. with a determiner they are not predisposed for. This kind of incongruency is enabled by a type shift (cf. Löbner 2011 for a detailed description of type shifts).

This way, the noun types are directly connected with two intensively discussed phenomena concerning nouns: definiteness marking on the one hand and the expression of possession on the other. For the latter, the so-called alienability distinction (Chappell and McGregor 1996; Heine 1997) can be seen as reflecting the distinction between inherently relational and inherently non-relational concepts grammatically (Gerland and Horn 2010; Löbner 2011). Languages exhibiting an alienability split use different constructions depending on the inherent (non-) relationality of the possessed noun. As Seiler (1983) points out, for inalienable possession (i.e. with inherently relational nouns) the morphological specification of the possessor is always closer to the possessum noun reflecting the closer conceptual relation between the two entities. For definiteness the distribution of definite articles and the use of two definite articles in some regional varieties of German reflect the distinction between inherently unique and non-unique nouns (cf. Ortmann, this volume, for a detailed analyses).

## 1.2 Contributions

The hypothesis that frames are not just an arbitrary format of representation but essential to human cognition is central to the majority of linguistic and philosophical contributions in this volume. Many of the papers also make ample use of frame representations, which – due to their expressive power – turn out as an efficient analytical tool for a wide range of phenomena. The first two contributions prepare the stage for the papers in this volume.

**Sebastian Löbner's** paper "Evidence for Frames from Human Language" starts out with two strong claims bundled together as the "Frame Hypothesis": (i) there is a common format for all representations in the human cognitive system and (ii) this format is frames in the sense of Barsalou's. Löbner argues that in addition to evidence from cognitive psychology there is also evidence from different levels of natural language which corroborates the Frame Hypothesis. In support of this claim, he discusses a number of universal uniqueness constraints which apply at the level of syntax and semantic composition. As a further corroboration of the Frame Hypothesis, he explores the development of abstract attributes in lexical semantics.

**Frank Zenker** investigates the applicability of the frame model to the analysis of scientific change in his paper "From Features via Frames to Spaces: Modeling Scientific Conceptual Change without Incommensurability or Aprioricity". Based on a discussion of various examples of taxonomic change, he reviews the capacity of the frame model. He discusses its origins in feature list models and then compares it to the alternative approach of conceptual spaces with a particular focus on the problem of the incommensurability of scientific paradigms. Since the structural invariants and constraints of frames naturally result from the geometry of the conceptual space, Zenker characterizes the conceptual spaces model as the most powerful model into which frames can easily be translated. However, he also concludes that the conceptual spaces approach may turn out to be too powerful in capturing taxonomic knowledge and that the choice of one model over the other may well be guided by the particular purpose.

### *1.2.1 Frame Analysis of Changes in Scientific Concepts*

Following Zenker's introductory paper, the contributions from the philosophy of science presented in this section apply frame representations in a number of case studies of paradigm change in natural science. In particular, they make use of the structuring potential of frames in representing the components of the theories of combustion, of heat and of light, by means of attributes which, for instance, capture theory-specific assumptions on the chemical reactions involved in combustion, the expansion of matter due to heat, or the taxonomies built upon different concepts of light. The resulting frame representations are characterized by a high degree of transparency and explicitness which allow for a systematic comparison of different accounts of the same phenomenon.

In their paper "Reconstructing Scientific Theory Change by Means of Frames", **Ioannis Votsis** and **Gerhard Schurz** address the applicability of frames to the analysis of different approaches to the phenomena of combustion and heat. They first compare the phlogiston and the oxygen theory as two successive theories of combustion and then discuss the transition from the caloric theory to the kinetic theory of heat. It turns out that frames are particularly apt for a comparison of scientific theories since they allow for a systematic decomposition of the theories

into attribute-value pairs. For example, the different explanations theories offer for phenomena such as calcination and salification and the thermal expansion, contraction and stability of bodies are translated into frame representations which permit a direct comparison of the essential ingredients of each account. The resulting frame representations of the phlogiston versus oxygen theory of combustion and the caloric versus kinetic theory of heat then help to reveal structural correspondence relations, which can be regarded as invariances in the sense of structural realism.

**Xiang Chen**'s paper "Interests in Conceptual Changes: A Frame Analysis" is based on the assumption that problem solving is driven by interest and that science is essentially problem solving. Chen investigates how the interests of particular scientists affected the replacement of the particle theory by the wave theory of light at the beginning of the nineteenth century. He argues that this process was to a large degree determined by the weight that proponents of the theories gave to specific attributes in the overall conception of these theories due to their specific interests. According to Chen the phenomenon of attribute weighting is best captured in the frame models of cognitive science since they allow for explicit reference to attributes. In particular, scientific attribute weighting is linked to Barsalou's analysis of ad hoc concepts which are constructed to achieve goals defined by interests. In spite of the important role of interest, Chen concludes that interests alone are not decisive for changes in scientific theory.

### *1.2.2 Event Frames and Lexical Decomposition*

The next two contributions are concerned with the semantic representation of verb-based event descriptions. They investigate the semantic decomposition of verb meaning in terms of event frames and inferential relations, respectively. The common assumption of both contributions is that predicative role frames in the sense introduced in Sect. 1.1.1 need to be extended, be it for a detailed analysis of the syntax-semantics interface or for employing them to draw inferences in textual entailment tasks. Such an extension needs to take into account the inherent structure of an event, including the representation of causal relations and resultant states. As indicated at the close of Sect. 1.1.1, frame representations do allow the reconciliation of predicative structure and a more detailed conceptual decomposition.

In their paper "FrameNet, Frame Structure, and the Syntax-Semantics Interface", **Rainer Osswald** and **Robert D. Van Valin, Jr.** take a close look at the Berkeley FrameNet project, which aims at implementing Fillmore's notion of frame semantics. Osswald and Van Valin critically examine to what extent the FrameNet approach in its present form can cope with its underlying goal of giving rise to an empirically grounded theory of the syntax-semantics interface. Based on a detailed study of verbs of cutting and separation and of the representation of events and results in FrameNet, they observe a certain lack of systematicity in the specification of frames and frame relations. For instance, the FrameNet frame 'Cutting' covers

only ‘cut apart’ scenarios but not ‘cut off’ scenarios, and the only frame which covers the latter event type is ‘Cause_harm’. The authors ascribe issues of this kind to the expectation that a system of frames can be developed on a data-driven, purely bottom-up account. As an alternative, the authors argue for a richer frame representation which takes into account the decompositional structure of an event in a systematic way.

Decomposing the meaning of event descriptions is also the central topic of “The Deep Lexical Semantics of Event Words” by **Jerry Hobbs** and **Niloofar Montazeri**. The authors begin with the observation that predicative frames like those of FrameNet provide a first approximation of what constitutes a situation type. Their approach of “deep lexical semantics” aims at decomposing such situation descriptions into more primitive elements, and at formalizing the interrelation between these elements by logical axioms. The overall goal is a formal theory of event components which includes general notions such as causation and change of state, but also elements derived from specific word senses. Such a theory can provide generalizations over event types in that closely related predicative frames can be characterized by similar sets of axioms. More importantly, the theory allows one to draw inferences between event descriptions and thus to build systems for textual entailment and natural language understanding in general, which is the main motivation behind Hobbs’ and Montazeri’s approach. As a basis for deriving the elements and axioms of their theory of word meaning, the authors build on CoreWordNet, a compilation of the most frequent and central concepts in English found within the WordNet database (Fellbaum 1998).

### *1.2.3 Properties, Frame Attributes and Adjectives*

While the papers in the preceding section deal with the representation of complex events referred to by dynamic verbs, the articles in this section are concerned with adjectives and stative verbs which lack internal temporal structure. Expressions of this type isolate particular object properties which translate into single frame attributes. For example, the adjectives *blue* and *young* denote values of the attributes COLOR and AGE, respectively. Likewise, stative verbs of perception such as *sound* and *feel* (*like*) encode the attributes SOUND and TOUCH the values of which are specified by adjectival complements such as *creaky* and *soft*, respectively. From a methodological point of view, lexemes of this kind are particularly interesting since they can be regarded as basic expressions which contribute the individual building blocks of frames. However, as becomes evident in the papers of this section, the straightforward translatability into single frame attributes is not always available since it is given only for a subset of the lexical items under discussion and also depends on their particular use.

The contribution of **Matthias Hartung** and **Anette Frank** “Distinguishing Properties and Relations in the Denotation of Adjectives: An Empirical Investigation” is concerned with the corpus-based classification of attributive adjectives into

property-denoting (*blue*, *comfortable*) and relational types (*economic*, *political*). The study is motivated by the fact that the modifiers of a noun can help to reveal information about the attributes of the denoted entity and of its relation to other entities, which can be employed for ontology learning from corpora. Hartung and Frank describe two studies on the corpus-based distinction between adjective types, one with human annotators and one with automatic classifiers. The human annotation task shows that the distinction between property-denoting and relational adjectives is fairly reliable with respect to inter-annotator agreement, while a further sub-classification of property-denoting adjectives into "basic" (*blue*) and "event-related" (*comfortable*) ones is not feasible. Moreover, the two-way distinction between properties and relations is shown to be learnable by an automatic classifier that uses contextual features.

In their contribution "Why Chocolate Eggs can Taste Old but not Oval: A Frame-Theoretic Analysis of Inferential Evidentials" **Wiebke Petersen** and **Thomas Gamerschlag** analyze perception verbs such as *taste (of)* and *look (like)*, which select an adjectival complement. In addition to the basic sensory use as in *taste bitter* and *feel soft*, perception verbs of this type often allow for a derived inferential use as in *taste old* and *feel expensive* in which the adjectival complement denotes a quality which is inferred by means of some sense-specific property indicated by the verb. Starting from the assumption that perception verbs of this type can be decomposed into single sense-specific frame attributes such as SOUND, TASTE, and SMELL, Gamerschlag and Petersen argue that a proper analysis of the inferential use necessarily involves reference to frame attributes, since this use is semantically well-formed only if the adjective specifies a value of an attribute which is inferable from the attribute encoded by the verb such as TASTE → AGE and TOUCH → PRICE. Technically, this kind of inferability is modeled as an inference structure defined on a type structure which represents the general knowledge of object properties. In addition, the authors assume that admissible inferential uses are distinguished from inadmissible uses by two constraints which operate on the type and inference structures.

### *1.2.4 Frames in Concept Composition*

The papers of this section investigate the compositional meaning of two kinds of complex nouns: nominal possessive constructions and nominal compounds. Both approaches are formulated in terms of frames, building on Löbner's claim of the cognitive adequacy of Barsalou frames. They derive the meaning of the complex nouns by means of different operations on the frames contributed by the parts of the construction in focus. As a general approach to the meaning of various subtypes of noun compounds Schulzek applies a frame transformation which relocates the central node of a frame thereby changing its referent. By contrast, Petersen and Osswald's approach to possessive constructions does not involve shifts of this type but rather applies unification of the frames contributed by the head noun and the

possessor noun in order to capture the process of argument saturation. Both accounts benefit from the specific structural properties of frames which facilitate the analysis of the composition of complex nouns in a "topographical" manner.

**Daniel Schulzek** applies Barsalou frames to the analysis of the meaning of complex nouns. In his paper "A Frame Approach to Metonymical Processes in some Common Types of German Word Formation", Schulzek analyses a broad range of nominal word formation phenomena, including possessive compounds such as *Lockenkopf* '(curls-head) curly head', synthetic compounds such as *Klavierspieler* 'piano player' and root compounds such as *Suppenlöffel* 'soup spoon'. Arguing that the meaning of these complex nouns is the result of metonymic shifts, Schulzek presents an approach in which the complex concepts that underlie these metonymic shifts are represented by frames. Metonymy is then captured by a frame transformation which shifts the central node of the frame to another node linked to it. Moreover, his account excludes non-admissible shifts by a frame constraint which demands that the two nodes involved in the frame transformation be connected by a bidirectional link.

In their paper "Concept Composition in Frames – Focusing on Genitive Constructions", **Wiebke Petersen** and **Tanja Osswald** offer a frame analysis of nominal possessive constructions such as *the age of John* and *friend of Mary* in which a noun is complemented by a genitive NP. Based on the distinction of the four different concept types for nouns proposed in Löbner (2011), they assume that a possessor argument appears with functional and true relational nouns and discuss the composition in possessive constructions in terms of frames. They show that the saturation of the possessor argument can be analyzed as the unification of the argument node of the relational frame with the central node of the possessor frame. Furthermore, they introduce an interpretation of frames in predicate logic which allows for a formalization of frame composition. They also address the question of how frames can aid in deriving the different kinds of relations expressed by genitive constructions (e.g. ownership, kinship and part-of relations).

### *1.2.5 Nominal Concept Types and Determination*

The contributions in this section deal with Löbner's (2011) system of concept types (cf. Sect. 1.1.3) and the grammatical phenomena related to the linguistic expression of these different types. The expression of unique reference is closely related to definiteness marking. The conditions under which definiteness markers occur have been discussed extensively in the linguistics literature. The first three papers in this section contribute to this discussion from different perspectives. The last paper investigates the question of whether the four noun types corresponding to the concept types characteristically occur in specific grammatical constructions which reflect their referential properties. In this way, the paper considers not only definiteness marking but also possession as an instance of determination.

**Doris Gerland** analyzes markers which usually indicate possession but also occur as definite articles. In her paper "Definitely not possessed? Possessive suffixes with Definiteness Marking Function", she explores the phenomenon of the so-called non-possessive use of possessive suffixes in Uralic languages. Showing that there is not enough evidence to consider the definiteness marking function of the suffixes as a result of a classical grammaticalization pathway, she proposes to analyze suffixes of this type as relational suffixes which have two functions: (i) linking the referent of the marked noun to (extra-)linguistic discourse and (ii) characterizing the referent of the noun as unique within this discourse. The conceptual noun type in the sense of Löbner (2011) and the respective context are identified as factors determining whether the suffix is interpreted as a marker of possession or as a marker of definiteness. This assumption is supported by examples from different text collections of Uralic languages.

The paper "Definite Article Asymmetries and Concept Types: Semantic and Pragmatic Uniqueness" by **Albert Ortmann** presents a typological approach to definiteness which analyzes the co-occurrence of inherently (non-)unique nouns and the definite article. Ortmann explores a number of different languages with respect to definite article asymmetries, instances of which are the use versus non-use of definite articles or article splits in languages with two definite articles such as Dutch, Swedish and some variants of German. Ortmann identifies two kinds of article splits, both reflecting Löbner's (1985) distinction between pragmatic (i.e. inherently non-unique) and semantic (i.e. inherently unique) definiteness. The splits follow a concept hierarchy (the 'scale of uniqueness') that is defined by the narrowness in the choice of possible referents. The cross-linguistic variation in the use of definite articles can thus be captured in terms of spreading along the concept hierarchy. This variation amends Löbner's (2011) scale of uniqueness and refines the distinction between inherently unique and non-unique concepts.

In her paper "The Indefiniteness of Definiteness", **Barbara Abbott** discusses the difficulties involved in establishing criteria for definiteness and the question of whether existing characterizations of this notion are able to capture its essence. She compares several traditional accounts which rely on criteria such as familiarity in the sense of Heim (1982), strength and uniqueness. She argues that some types of NPs, such as universally quantified NPs, partitives, possessive NPs and specific indefinites, raise issues concerning definiteness even though they do not belong to the group traditionally classified as definite NP (such as proper names, definite descriptions, demonstrative descriptions, and pronouns). Abbott concludes that although Russell's uniqueness characteristic holds up well against the other accounts, the use of a single definiteness criterion is not sufficient.

The paper by **Christian Horn** and **Nicolas Kimm** analyzes definiteness and possession as linguistic expressions of the referential properties of noun types. In their paper "Nominal Concept Types in German Fictional Texts" they pursue the question of whether Löbner's (2011) assumption of the predisposed use of concept types is corroborated statistically, i.e. whether the referential properties of concept types are reflected by a small set of morphosyntactic features that are observable on the linguistic surface. In their corpus study, they use a manually annotated

collection of German texts. Their statistical analysis shows that relational nouns (i.e. relational and functional nouns) occur more often in possessive constructions than non-relational (i.e. sortal and individual) nouns. Within the group of relational nouns, functional nouns show a higher percentage for definite and singular use than relational nouns which are not functional. The results of the investigation support the system of the four different concept types.

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