Chapter 6
FrameNet, Frame Structure, and the Syntax-Semantics Interface

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Abstract The Berkeley FrameNet project aims at implementing Fillmore's Frame Semantics program on a broad empirical basis. The syntactic environments of words in corpora are systematically aligned with the semantic frames evoked by the words. It is Fillmore's vision that such a collection of valency data can pave the way for an empirically grounded theory of the syntax-semantics interface. In this article, we examine to what extent this goal can be achieved by the FrameNet approach in its present form. We take a close look at verbs of cutting and separation and at the representation of events and results in the latest FrameNet version. Our investigation reveals a certain lack of systematicity in the definition of frames and frame relations, which may hinder the derivation of linking generalizations. This situation seems to be partly due to the expectation that a system of frames can be developed on a data-driven, purely bottom-up account. As a possible solution, we argue for a richer frame representation which systematically takes into account the inner structure of an event and thereby inherently captures structural relations between frames.

Keywords Syntax-semantics-interface • FrameNet • Relations between frames • Structure of frames

6.1 Introduction

In the context of lexical semantics, the notion of frame is mostly associated with the research program known as Frame Semantics initiated by Charles Fillmore (1982). Its basic idea is that words, in each of their senses, are linked to frames, which are schematic cognitive structures that represent a speaker's knowledge of the described

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situation or state of affairs. An important part of the program is to study in detail how the components of the frames are expressed in the morphosyntactic environment of the word. To this end, the relationships between word senses and lexico-syntactic patterns are systematically recorded, and each of these patterns has its components indexed with specific parts of the associated frame (Fillmore and Atkins 1992).

Frame Semantics has been put into practice in the Berkeley FrameNet project (Fillmore et al. 2003, Fillmore and Baker 2010). The main goal of FrameNet is to systematically collect syntactic and semantic valency patterns based on extensive corpus annotation. In this respect, the focus of the project is first and foremost descriptive. But the project has also an important "inventive" part in providing appropriate frames for the annotation. While there are a number of guidelines for introducing frames based on identifying groups of semantically related words (Ruppenhofer et al. 2010, Chap. 2), there is no explicated framework of semantic analysis for the specification of more abstract frames and frame-to-frame relations. We will see below that many inconsistencies in FrameNet's frame structure may be attributed to this lack of a general top-down strategy.

Fillmore (2007) characterizes the FrameNet project as an empirical investigation into the interplay between lexical semantics and morphosyntactic realization. As with any scientific investigation, the point is not only to sample as much data as possible but also to look for regularities and generalizations, that is, for a theory that explains the data. The theory in question is a theory about argument linking and the syntax-semantics interface of lexico-syntactic constructions. In fact, Fillmore has the vision that Frame Semantics as implemented in FrameNet can provide a basis for deriving linking generalizations. The underlying assumption is that FrameNet will ultimately be equipped with an elaborate frame hierarchy and that linking generalizations can then be formulated in terms of abstract frames for action, change, causation, and the like.

We will critically examine whether Fillmore's vision is supported by the present architecture of FrameNet.[1] A crucial problem turns out to be the relative lack of systematicity in semantic analysis. We provide evidence for this claim by revealing various deficiencies in the frame representation of causation and inchoation and of events and changes in general, and in the representation of verbs of cutting and separation. We sketch how a more explicit decompositional approach to frame semantics could potentially overcome many of these problems. In particular, we argue that the internal structure of an event or state of affairs should be reflected within the frame representation itself. We will also point out that FrameNet's current restriction to associating frames with lexical items may run into difficulties even for elementary constructional variations.

[1] It is worth mentioning that FrameNet has gained some popularity among computational linguists as a lexical semantic resource in systems for textual inference and the like. This is not surprising in view of the fact that most current natural language understanding systems combine various, often statistically trained processing components and are in need of any kind of information about lexical semantic classes and possible paraphrases.

All FrameNet data discussed in the following are taken from FrameNet Version 1.5 of September 21, 2010, which includes more than 1,000 frames, almost 12,000 word senses (lexical units), and over 8,000 instances of frame-to-frame relations. We speak of 'FN 1.5', if we refer to this specific release, and of 'FrameNet', if we mean the project in general. A word of caution: We are fully aware that an intermediary release of an ongoing large-scale project like FrameNet inevitably shows gaps and inconsistencies.[2] We therefore try to distinguish between temporary issues that can easily be remedied during the next revision cycle and potential inherent problems of the approach itself. Despite its shortcomings, we regard the FrameNet project as an important contribution to developing an empirically grounded theory of lexical semantics and linking. And, of course, the present study would not have been possible without the generous policy of the FrameNet group to make their data publicly available.

6.2 Frame Semantics and FrameNet

6.2.1 From Case Frames to Frame Semantics

Fillmore's (1968) early 'case grammar' approach builds on the concept of *case frames*, whose underlying idea was to characterize the valency of verbs by a small set of semantic roles from which the syntactic valency can be predicted by general rules. In later writings, Fillmore conceded that this approach falls short in several respects (cf. Fillmore 2003). For one thing, it turned out to be difficult, if not impossible, to come up with a stable inventory of semantic case roles together with reliable criteria for assigning them to the participants of the situation described by a verb or any other valency bearing lexical item. Another issue is the unique role assignment in cases of complex event descriptions like (1), where *the ball* is both the Goal of the 'hitting' component and the Theme of the 'go-over' component.

(1) Peter knocked the ball over the fence.

As a consequence, the notion of frame laid out in his *Frame Semantics* approach (Fillmore 1982) aims at a much broader and deeper conceptual-semantic description of lexical items than provided by course-grained semantic role frames. *Frames* in this context are to be understood as "schematic representation[s] of speakers' knowledge of the situations or states of affairs that underlie the meanings of lexical items" (Fillmore 2007, p. 130) or as "situation types for which the language

[2] A good part of the FrameNet data has been gathered by full text annotation (Ruppenhofer et al. 2013), which is a particularly demanding and, hence, error-prone task.

has provided special expressive means" (Fillmore and Baker 2010, p. 321).[3] The program of Frame Semantics has been elaborated in a series of detailed case studies on the meaning and use of individual verbs and narrow verb classes (cf., e.g., Fillmore and Atkins 1992). Although these studies emphasized the correlation of particular lexical meanings with specific morphosyntactic patterns, they did not aim at an explanatory account of the relation between (morpho-)syntax and semantics. In particular, no attempt has been made to derive generalizations on this interaction that go beyond the discussion of selected examples.

6.2.2 The FrameNet Project

The FrameNet project, which started in the late 1990s, is intended as a broad coverage, corpus-based implementation of the Frame Semantics program (Fillmore et al. 2003, Fillmore and Baker 2010). According to Fillmore (2007, p. 129), the project's main focus is on valency descriptions in syntactic and semantic terms, that is, on exploring the correlation between lexical semantics and syntactic argument realization:

> The FrameNet project is dedicated to producing valency descriptions of frame-bearing *lexical units* (LUs), in both semantic and syntactic terms, and it bases this work on attestations of word usage taken from a very large digital corpus. The semantic descriptors of each valency pattern are taken from frame-specific semantic role names (called *frame elements*), and the syntactic terms are taken from a restricted set of grammatical function names and a detailed set of phrase types.

Frames in the context of FrameNet are thus plain semantic role frames, similar to the earlier case frames, except that there is no universal role inventory anymore since the semantic roles are specific with respect to the frame they belong to.

6.2.2.1 The Specification of Frames in FrameNet

The description of a frame in the FrameNet database includes the following components: the name of the frame; an informal definition of the situation the frame is supposed to represent; the set of semantic roles (*frame elements*) associated with the frame, subdivided into *core* and *non-core* elements; and the corresponding word senses (*lexical units*) that evoke the frame. Core roles are those which are "necessary to the central meaning of the frame" (Fillmore 2007, p. 133). Non-core roles are subdivided into *peripheral* and *extrathematic* elements. Peripheral roles mark notions such as time, place, manner, means, and the like. They are not unique

[3] Similarly, Fillmore and Baker (2010, p. 317): "In Frame Semantics, the meaning dimension is expressed in terms of the cognitive structures (frames) that shape speakers' understanding of linguistic expressions."

Table 6.1 Partial description of the Cutting frame in FN 1.5

Cutting

Definition: An [Agent] cuts an [Item] into [Pieces] using an [Instrument] (which may or may not be expressed).

Core frame elements:

Agent	The [Agent] is the person cutting the [Item] into [Pieces].
Item	The item which is being cut into [Pieces].
Pieces	The [Pieces] are the parts of the original [Item] which are the result of the slicing.

Non-core frame elements:

Instrument	The [Instrument] with which the [Item] is being cut into [Pieces].	
Manner	[Manner] in which the [Item] is being cut into [Pieces].	
Result	The [Result] of the [Item] being sliced into [Pieces].	(extrathematic)
In addition: Means, Purpose, Place, Time		

Lexical units: *carve*, *chop*, *cube*, *cut*, *dice*, *fillet*, *mince*, *pare*, *slice*

to a frame but can modify any frame of the appropriate type. Extrathematic roles are used to annotate a "word or phrase which can be thought of as introducing a new frame, rather filling out the details of the frame evoked by the head" (Fillmore 2007, *ibid.*). An example of an extrathematic role is Depictive, which is used to mark depictive secondary predicates. Furthermore, FrameNet allows the characterization of "role fillers" by semantic types.

Table 6.1 shows part of the specification of the Cutting frame, which is evoked by (appropriate senses of) the verbs *cut*, *chop*, etc. The element Result is the only extrathematic role among the non-core elements. Some of the frame elements carry semantic types, which are not shown in the Figure. For example, Agent and Instrument are typed as Sentient and Physical_entity, respectively.

6.2.2.2 Annotation Scheme

One of the goals of FrameNet is to provide all lexical units of a frame with a representative set of corpus-based example sentences, which are annotated both syntactically and semantically. The semantic annotation consists basically in the assignment of frame elements to constituents of the example sentences. The syntactic annotation comprises a phrasal and a functional level. The phrasal level employs fairly standard phrase type markers (NP, PP, AVP, etc.; cf. Atkins et al. 2003), while the functional level uses grammatical functions such as External, Object, and Dependent.

The sentences in (2) are corpus examples from FN 1.5 that are associated with the lexical unit *slice* of the frame Cutting.

(2) a. Slice the cake lengthwise into two halves, to give two long, thin cakes.
b. Slice the onions fairly fine.
c. The frozen brain is [...] sliced sequentially into very thin sections.

The annotation report for sentence (2a) is shown in (3). CNI stands for 'constructional null instantiation', which indicates that the core role Agent is omitted on syntactic grounds, here, because of the imperative.[4]

(3)

	Item	Manner	Pieces	Purpose	Agent
Slice	the cake	lengthwise	into two halves,	to give two long, thin cakes.	CNI
	NP	AVP	PP[into]	VPto	
	Obj	Dep	Dep	Dep	

6.2.2.3 Frame-to-Frame Relations

FrameNet frames are not isolated units but are related to each other in various ways. FrameNet employs eight different types of relations between frames, of which seven are relevant to the present study. They fall into three groups (Fillmore and Baker 2010): generalization relations (inherits from, is perspective on, uses), event structure relations (is subframe of, precedes), and "systematic" relations (is causative of, is inchoative of).[5]

Inheritance is the strongest relation between frames. If a frame (the *child* frame) inherits from another frame (the *parent* frame) then all frame elements (semantic roles) of the parent frame occur as frame elements of the child frame, possibly under a different name. The possible difference in naming reflects the fact that FrameNet assumes frame-specific semantic roles. In the case of inheritance, the semantic type of the child is a subtype of the parent, and the same condition holds for all role filler types. For example, the frame Cutting inherits from the frame Intentionally_affect, with the Item element of Cutting bound to the Patient element of Intentionally_affect and all other element names kept equal. And the frame Commerce_buy inherits from Getting, with the roles Buyer, Goods, and Seller bound to Recipient, Theme, and Source, respectively. Figure 6.1 shows a simplified representation of these examples, with only some of the core roles listed. Frames are depicted as attribute-value matrices and co-indexing indicates the correspondence between roles.

[4]The FrameNet annotations identify two further types of omissions of core frame elements, called *definite* and *indefinite null instantiations*; cf. Fillmore (1986).

[5]The eighth relation is the 'See also' relation, which is used for cross-referencing purposes.

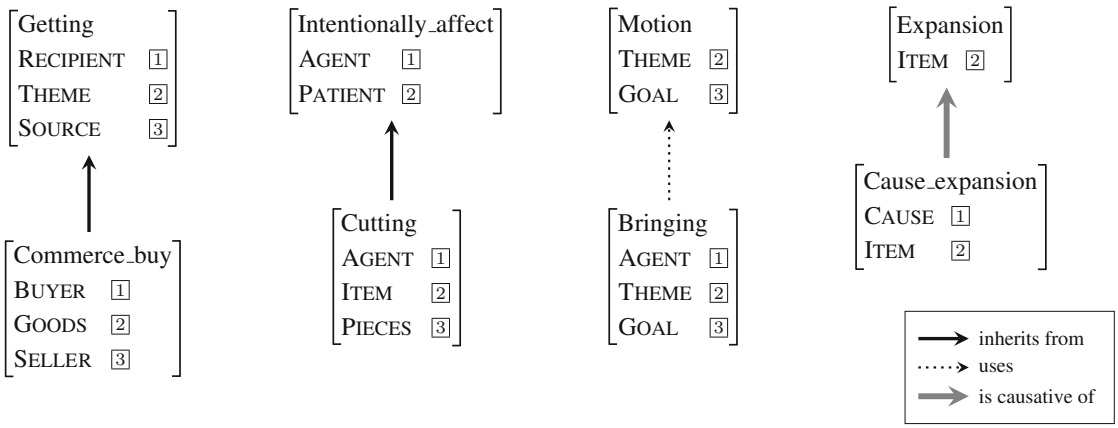

Fig. 6.1 Simplified examples of frame-to-frame relations in FN 1.5

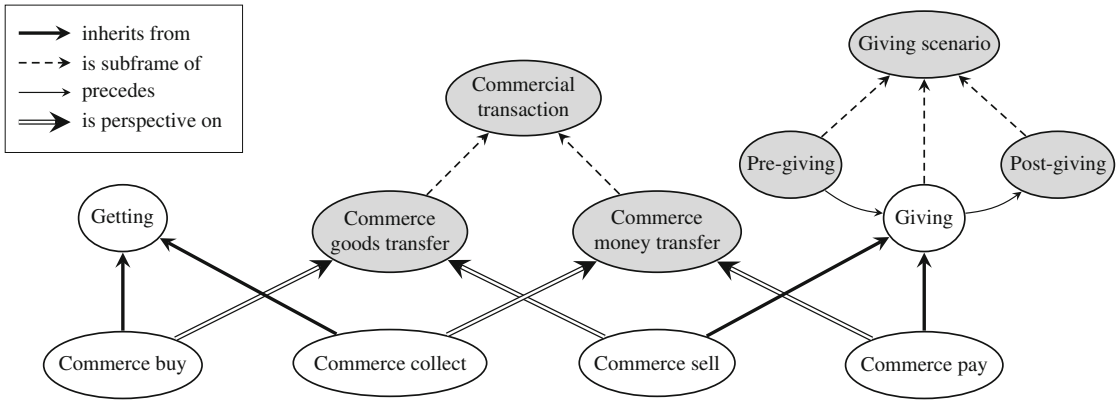

Fig. 6.2 Commercial transaction in FrameNet (*shaded nodes* indicate non-lexical frames)

The 'is perspective on' relation implements the ideas of profiling and figure/ground distinction.[6] A widely discussed example in the FrameNet literature is the commercial transaction scenario, where buying and selling are regarded as taking different perspectives on the transfer of goods, while paying and collecting take different perspectives on the transfer of money[7]; see Fig. 6.2. Frames that have perspectives are often abstract or *non-lexical* in that they are not directly evoked by lexical units but via one of their perspective-taking frames.

The 'uses' relation is defined somewhat vaguely. According to Ruppenhofer et al. (2010, p. 78), this relation "is used almost exclusively for cases in which a part of the scene evoked by the Child refers to the Parent frame", Fillmore and Petruck (2003, p. 361) describe it as a "relation like Inheritance, but less strictly defined", and Fillmore and Baker (2010, p. 330) posit that the child frame "depends upon

[6]Cf. Fillmore et al. (2001, p. 16): "Profiling [...] is the presentation of the foregrounded part of a frame [...] which figures centrally in the semantic interpretation of the sentence within which the frame is evoked."

[7]But see Van Valin (1999, p. 387), where it is argued that *buy* and *sell* are not simple shifts of perspective.

background knowledge provided by the parent frame" and that some but not all of the core roles of the parent must correspond to roles of the child frame. For instance, the frames Bringing and Removing use the frame Motion with the Agent role of Bringing and Removing not bound to any role of Motion, while the roles Theme, Goal, Path, and several others have direct correspondents (cf. Fig. 6.1).

The 'is subframe of' relation holds between a pair of frames if the first frame represents a subevent of the (complex) event represented by the second frame. Figure 6.2 shows two instances of subframe structures. The frame Commercial_transaction has the subframes Commerce_goods_transfer and Commerce_money_transfer. Apparently, there is no clear temporal precedence between the events denoted by these two subframes. This is different for the subframes of the Giving_scenario frame. They represent a temporal succession of states and events, which is indicated by the 'precedes' relation.[8] Note that it remains unclear how exactly "subevent" in the subframe definition differs from "part of the scene" in the 'uses' definition.

The 'is inchoative of' and 'is causative of' relations, finally, hold between pairs of frames of which the first denotes respectively the inchoative and the causative of the event denoted by the second frame. For instance, the frame Cause_expansion is causative of the frame Expansion, and Becoming_detached is inchoative of Being_detached. The two relations will be discussed in more detail in Sect. 6.3.2.[9]

6.2.3 Frame Semantics and Linking Generalizations

Fillmore's early case frame approach was a proposal to explain the morphosyntactic realization of a verb's arguments in terms of general semantic characteristics of the verb. Because of the problems mentioned in Sect. 6.2.1, Fillmore abandoned the idea of universal case roles in favor of his Frame Semantics program with its richer notion of lexical meaning and its dedication to a broad coverage of realization patterns. Exploring the regularities of the interaction between lexical semantics and morphosyntax nevertheless continues to be an essential goal of the program, and thus also one of the FrameNet project. Accordingly, Fillmore (2007, p. 157) assumes that FrameNet can give rise to linking generalizations if abstract frames and frame-to-frame relations are appropriately defined:

> The structure of the system of frame-to-frame relations is set up, but the details have not been completed as of this writing. *Many FrameNet frames are elaborations of more*

[8] Although not shown in Fig. 6.2, the Getting frame is part of a similar change scenario. The easiest way to get an overview of the frame relations in FrameNet is to use the FrameGrapher tool available at the project website http://framenet.icsi.berkeley.edu. (Note that the online version might differ from the FN 1.5 release discussed here.)

[9] For a more formal analysis of the FrameNet relations in terms of logical axioms see Scheffczyk et al. (2010) and Ovchinnikova et al. (2010).

> *abstract schemas of change, action, movement, experience, causation, etc., and the roles found in these are the ones that figure in linking generalizations;* many of the more refined frames can be seen as perspectives on the more abstract frames, in the way that buying is a subtype of getting, selling and paying are kinds of giving, etc. Generalizations based on inferences about who possesses what before and after the transaction depend on the roles in the commercial transaction; *generalizations about how syntactic roles are assigned to the arguments depend on the more abstract inherited schemas.* [emphasis added][10]

Fillmore and Baker (2010, pp. 332f) illustrate this idea with an example from the commercial transaction scenario shown in Fig. 6.2. They argue that the verbs *buy* and *collect* are used with the preposition *from* because "buying and collecting are getting," and that *sell* and *pay* allow the dative alternation because "selling and paying are giving." That is, the fact that Commerce_buy and Commerce_collect inherit from Getting is employed to explain the respective realizations of the Seller and the Buyer by a *from*-PP. A glance at Commerce_collect in FN 1.5 shows some of the complications this proposal is faced with in practice. The Commerce_collect frame has the units *bill*, *charge*, and *collect* (of which only *charge* is annotated). Neither *bill* nor *charge* allow the "getting-from" pattern – simply because none of them is a getting verb. Billing and charging have to do with communicating the demand for money to the buyer. Hence, *bill* and *charge* are more like verbs of giving and, in fact, *charge* allows the dative alternation. What we have encountered here is a defect in FN 1.5 but not necessarily one in FrameNet. The problem can be remedied by removing *bill* and *charge* from Commerce_collect, thereby keeping the inheritance from Getting. Now, what to do with *bill* and *charge*? Clearly, these verbs should evoke some frame in the commercial transaction domain. But the frame system shown in Fig. 6.2 is not subtle enough to cover the respective component of a commercial transaction, which could roughly be described as "assigning debt of payment." This discussion illustrates that while frame inheritance might indeed give rise to linking generalizations, the approach is very sensitive to the adequate specification of frames and frame-to-frame relations.

6.3 The Representation of Events and States

6.3.1 Events and Changes

According to Fillmore and Baker (2010, p. 331), FrameNet adopts, for the most part, a "simple three-state model of event structure, with a pre-state, a central change, and a post-state," of which "typically, only the central, changing part of the event is

[10] In an earlier, more programmatic publication on the FrameNet project, one of its central goals is described as follows: "As much as possible, we wish to show that the particular valence profiles of individual words can often be best understood with reference to the multiple frames which enter into their semantic structure." (Fillmore and Atkins 1998).

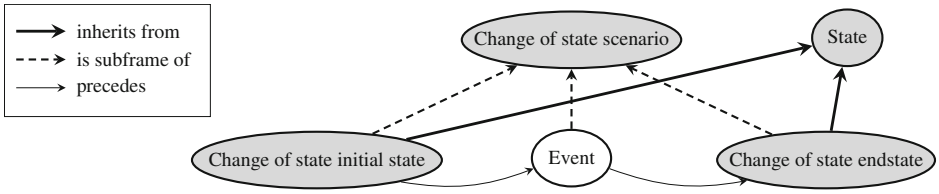

Fig. 6.3 FN 1.5 top level event structure (*shaded nodes* indicate non-lexical frames)

profiled, and, hence lexicalized." We have seen this structure in Fig. 6.2 instantiated by the Giving_scenario frame and its subframes. Its abstract correlate is shown in Fig. 6.3. The precise interpretation of this frame-to-frame structure in terms of the represented situation types raises a number of questions. Does the structure in Fig. 6.3 imply that each situation of type Event is necessarily part of a situation of type Change_of_state_scenario? If yes, then this property should somehow be reflected in the definition of the Event frame. According to the FN 1.5 definition shown in Table 6.2, nothing seems to be required of situations of type Event except that something happens; that is, situations of this type are dynamic, not static. Correspondingly, the associated verb units are general verbs of occurrence such as *happen* and *take place*.

There are basically two ways of conceiving the Event frame in its relation to change of state scenarios. On one interpretation, the frame covers all kinds of dynamic situations, including processes and activities like motion in place (*rotate*, *vibrate*) and directed perception (*watch*, *listen*), which are usually not regarded as changes of state in the proper sense. On a second, more restrictive interpretation, any situation of type Event involves a *conceptually salient* change, typically manifested on one of the participants.[11] The two options should give rise to different sets of frames that inherit from Event. The direct inheritance daughters of Event in FN 1.5 are shown in (4).

(4) Becoming, Birth, Ceasing_to_be, Change_of_consistency, Coming_to_believe, Eventive_affecting, Experience_bodily_harm, Getting, Go_into_shape, Intentionally_act, Misdeed, Process_end, Process_pause, Process_resume, Process_start, Process_stop, Rotting, Transitive_action, Waking_up.[12]

The first thing to notice about this list is its heterogeneity. We can ascribe this to the fact that FrameNet is still under construction, and presumably also to the lack of an elaborate and precise guideline on how to organize the frame inheritance hierarchy. As to the question of whether Event subsumes all sorts of events or only changes of state, the frames listed in (4) give a mixed impression. The wide interpretation of Event is supported by the fact that Intentionally_act is inherited by

[11] Note that it is not the physicalistic notion of change which is relevant here. In the physical sense, progression of time is always accompanied by changes of state.

[12] As of January 25th, 2012, the frames Motion and Objective_Influence have been added to this list.

Table 6.2 Definitions of general situation frames in FN 1.5, with associated verb and noun units

Event: An [Event] takes place at a [Place] and [Time].
go on, *happen*, *occur*, *take place*, *transpire*; *development*, *event*
State: An [Entity] persists in a stable situation called a [State].
(Non-lexical)
Change_of_state_scenario: This frame denotes simple [Event]s in which an [Entity] punctually or continually changes in the direction of the Endstate.
(Non-lexical)
Change_of_state_endstate: The endstate of a simple event X-schema.[13]
(Non-lexical)
Becoming: An [Entity] ends up in a [Final_state] or [Final_category] which it was not in before.
become, *end up*, *form*, *get*, *go*, *grow*, *turn*
Process: This frame describes a complex event which lasts some amount of time, consisting of a beginning stage, a stage where the process is ongoing, and a finish or end. In some cases the process may pause, and then possibly resume.
process (N)
Activity: This is an abstract frame for durative activities, in which the [Agent] enters an ongoing state of the [Activity], remains in this state for some [Duration] of [Time], and leaves this state either by finishing or by stopping. The [Agent]'s [Activity] should be intentional.
(Non-lexical)
Intentionally_act: This is an abstract frame for acts performed by sentient beings. It exists mostly for FE inheritance.
act, *carry out*, *conduct*, *do*, *engage*, *execute*; *action*, *activity*, *act*, *actor*, *agent*, *doing*, *measures*, *move*, *perform*, *step*

Perception_active (*watch*, *listen*) and Practice (*practice*, *rehearse*), both of which do not count as proper change of state frames in the sense discussed above. On the other hand, the frame Process_continue (*go on*, *proceed*) is not included in the list (nor subsumed by one of its members) and neither is Moving_in_place (*rotate*, *vibrate*). Moreover, there are obvious cases of change of state frames such as Undergo_change (*change*, *turn*) and Change_of_phase (*freeze*, *melt*) which do not inherit from Event. In sum, FN 1.5 provides no coherent picture about how dynamic situations are to be distinguished with respect to their change-of-state character. It is also indicative that the frame Process and its inheritance daughter Activity are not systematically employed for structuring the inheritance hierarchy. And the same is true of the frame Becoming, which is inherited by a single frame only, namely, Absorb_heat.

The foregoing shortcomings of the FN 1.5 frame hierarchy may be remediable to some extent by a thorough revision and extension of the frame-to-frame inheritance

[13] 'X-schema' is short for 'executing schema'; cf., e.g., Chang et al. (2002)

relations.[14] For instance, if the Event frame is to be conceived of as covering all kinds of dynamic situations, then it seems reasonable to require that every frame representing a dynamic situation type inherits (directly or indirectly) from Event. In this case, the above observations that some dynamic situations are not subsumed by Event would simply be due to missing inheritance relations which remain to be added to the database. The frames Process, Activity, Change_of_state_scenario, etc. would then all inherit from Event. But the question as to whether there is a distinction between event frames that inherently encode a goal or result and those which do not still needs to be answered. Put differently, is the telic/atelic distinction, or a more refined Aktionsart classification, part of the representation of situation types in FrameNet? Whatever the answer is, there should be clear criteria for deciding whether a given situation type is subsumed by, say, Process, Change_of_state_scenario, or none of the two. In fact, there are good reasons to have Aktionsart distinctions represented in FrameNet because of their relevance both for natural language reasoning (Im and Pustejovsky 2010) and for formulating generalizations about the syntax-semantics interface (Van Valin 2005).[15]

6.3.2 Causatives and Inchoatives

The names of about 30 frames in FN 1.5 start with 'Cause'. They range from general frames like Cause_change (with lexical units *alter*, *change*, *convert*, *modify*, *turn*, etc.) to fairly specific ones like Cause_to_wake and Cause_to_be_dry. As to be expected, many of these "cause" frames are causatives of other frames; e.g., Cause_change is causative of Undergo_change (*change*, *shift*, *turn*, etc.). Further causative pairs are listed in Table 6.3. The verbs in the right column occur in both frames, that is, they undergo the causative-inchoative alternation. A number of the "Cause frames" are not causatives of other frames, even if there are clear candidates available. For example, there is no 'is causative of' relation between the frames Cause_to_wake and Waking_up. Also, one would expect that the frames Cause_change and Undergo_change are somehow related to – if not inherited by – more specific frames such as Cause_change_of_phase and Change_of_phase, respectively, which is not the case. As to inchoatives, there are transparent chains from causative to inchoative to result state as illustrated by the following examples:

[14]The frame-to-frame relations in the FrameNet database are subject to continuous revision; cf. Petruck et al. (2004).

[15]It is worth mentioning that the foundational upper-level ontology DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering; cf. Gangemi et al. 2002), which is used by Ovchinnikova et al. (2010) in their ontological analysis of FrameNet, basically follows Vendler's (1957) Aktionsart typology in subdividing situations ("perdurants") into events and statives, events further into accomplishments and achievements, and statives into states and processes.

Table 6.3 Some causative-inchoative pairs in FN 1.5, together with alternating verb units

Cause_change	Undergo_change	*change*, *turn*
Cause_change_position_on_a_scale	Change_position_on_a_scale	*grow*, *increase*
Cause_temperature_change	Inchoative_change_of_temperature	*cool*, *heat*, *warm*
Cause_change_of_phase	Change_of_phase	*freeze*, *liquefy*, *melt*
Cause_change_of_consistency	Change_of_consistency	*clot*, *harden*, *thicken*
Cause_expansion	Expansion	*grow*, *lengthen*
Cause_to_move_in_place	Moving_in_place	*rotate*, *spin*, *vibrate*
Cause_fluidic_motion	Fluidic_motion	*drip*, *splash*
Attaching	Inchoative_attaching	*attach*, *stick*
Detaching	Becoming_detached	*detach*, *unhook*
Cause_to_amalgamate	Amalgamation	*fuse*, *meld*, *unify*
Separating	Becoming_separated	*separate*, *split*

(5) a. Attaching, Inchoative_attaching, Being_attached
b. Cause_temperature_change, Inchoative_change_of_temperature, Temperature
c. Cause_change_position_on_a_scale, Change_position_on_a_scale, Position_on_a_scale

But it also happens that the inchoative frame is missing in the chain: Cause_to_be_dry is causative of Being_dry and the frame Becoming_dry is not related to either of the them (cf. Table 6.4 and the discussion in Sect. 6.3.3 below).

As in the case of event inheritance discussed in the previous section, one might argue that the foregoing deficiencies could be easily remedied without changing the present set-up of the FrameNet project by successively adding missing frames and frame-to-frame relations and by eliminating inconsistencies. The point we want to make is that this task could strongly profit from a systematic decompositional analysis of event frames. Notice that decompositional structure is already captured in FN 1.5, to some extent, by the naming of the frames. Several names of the causative frames listed in Table 6.3 are regularly built from the names of their inchoative correlates by adding the prefix 'Cause'. However, there is obviously no general convention for naming frames – compare, e.g., Inchoative_attaching vs. Becoming_detached. While naming is, in principle, irrelevant to the content of FrameNet, a consistent naming convention would help to avoid many of the deficiencies of the 'is causative of' and 'is inchoative of' frame-to-frame relations mentioned above. Whether one of these relations holds between two frames could then be deduced from the names of the frames. Also, cases like Becoming_dry being not related to Being_dry would not occur. One of the arguments in favor of a decompositional frame analysis is thus the inherent support for organizing the frame hierarchy in a systematic way. A second argument, to be sketched in Sect. 6.3.3 below, is the role the decompositional structure can play in deriving linking generalizations.

A more intricate issue for the systematic treatment of causation and inchoation turns up with the Change_of_phase frame and its associates. As shown in Fig. 6.4,

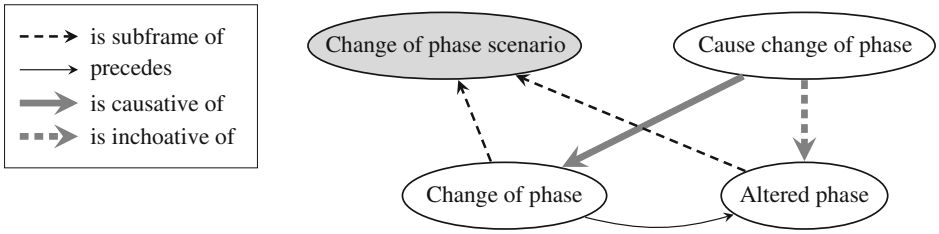

Fig. 6.4 FrameNet frames representing changes of phase

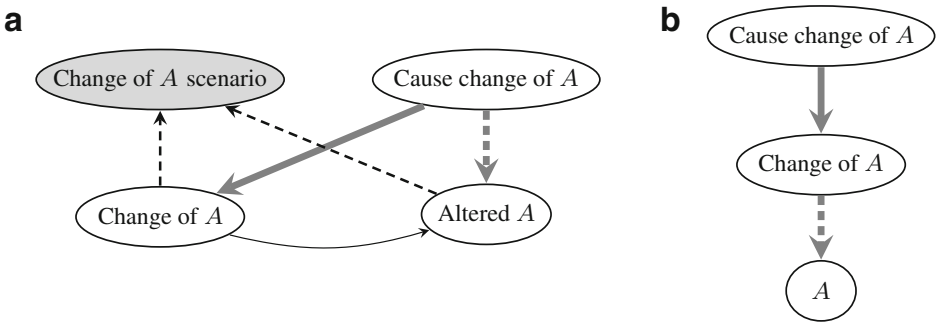

Fig. 6.5 Different FN 1.5 representations of the causation/inchoation/state pattern

Table 6.4 Definitions of FN 1.5 frames of drying, with associated verb and adjective units

Cause_to_be_dry: An [Agent] causes a [Dryee] (. . .) to become dry. . . .
anhydrate, *dehumidify*, *dehydrate*, *desiccate*, *dry off*, *dry out*, *dry up*, *dry*
Becoming_dry: An [Entity] loses moisture with the outcome of being in a dry state.
dehydrate, *dry up*, *dry*, *exsiccate*
Being_dry: An [Item] is in a state of dryness.
dehydrated, *desiccated*, *dry*, *parched*, *waterless*

the causative frame is inchoative of the frame Altered_phase (*frozen*, *liquefied*, *melted*, etc.), which is preceded by the frame Change_of_phase, and there is an additional "scenario frame" with Change_of_phase and Altered_phase as subframes. Figure 6.5a depicts the general structure behind Fig. 6.4, namely the change of an object with respect to an attribute A – here, the object's phase or state of matter. By comparison, the corresponding case of the attribute temperature (5b) follows basically the pattern shown in Fig. 6.5b. The state characterizations in (a) and (b) differ substantially: States of affairs of type 'A' are about an entity having its attribute A specified to a certain value. For instance, the Temperature frame has the adjective units *cold*, *hot*, *warm*, etc., which can be used to characterize the temperature of an entity, either in pre-nominal position or in a copula construction. States of affairs of type 'Altered A', by contrast, depend on a previous alteration event. If applied to temperature, the respective "Altered temperature" frame would presumably cover the participles *cooled*, *heated*, and *warmed*. The frame structure

shown in Figs. 6.4 and 6.5a conceives of the resulting state as being a part of a change of state scenario in much the same way as outlined by the general event model in Fig. 6.3. The question, then, is whether all change of state frames are sought to be systematically paired with corresponding result state frames and, even more crucially, how these result frames are related to their event-independent counterparts, if existent.[16] That is, should FrameNet provide different state frames for *dried* and *dry*, *warmed* and *warm*, or *liquefied* and *liquid*, respectively?[17] In the following section, we will argue that these issues can be resolved, up to a point, by representing the components of an event type within the frame itself.

6.3.3 *Toward a Decompositional Frame Semantics*

Many current theories of the syntax-semantics interface rely on semantic decomposition.[18] Almost all of these proposals involve relatively shallow, term-based decompositions. Two notational variants of such a decomposition of causative *dry* are shown in (6), formulated along the lines of Van Valin and LaPolla (1997) and Rappaport Hovav and Levin (1998), respectively.

(6) a. [**do**$(x, \varnothing)$] CAUSE [BECOME **dry**(y)]

b. [x ACT] CAUSE [BECOME [y $\langle DRY \rangle$]]

Decompositional representations of this type try to make explicit the semantic factors that play a role in argument realization, including causal and aspectual factors as well as notions such as volitionality and the like. Many theories of linking are based on semantic decompositions of this sort. For example, the linking theory of Van Valin and LaPolla (1997) regards specific and generalized semantic roles as derived notions that can be defined on the basis of the structural positions in the decompositional representations. In this approach, the generalized roles Actor and Undergoer play a key role in explaining the linking of arguments to their morphosyntactic realization.

As discussed in the previous section, a naming convention for frames is a simple but limited method of capturing the sub-eventual structure of a situation. A more attractive and more sophisticated option is to represent the structure within

[16] This distinction is similar to that between resultant states and target states proposed by Parsons (1990).

[17] The online version of the FrameNet database of January 25th, 2012, has Altered_phase renamed to Substance_by_phase, with the adjectives *gaseous* and *liquid* and the nouns *gas* and *liquid* added, among others. The basic dichotomy between the two structures shown in Fig. 6.5 nevertheless persists (not to mention the additional problem that the new name suggests that the frame should inherit from Substance and thereby from Physical_entity, which seems fully at odds with the structure shown in Fig. 6.4).

[18] See Levin and Rappaport Hovav (2005) for an overview.

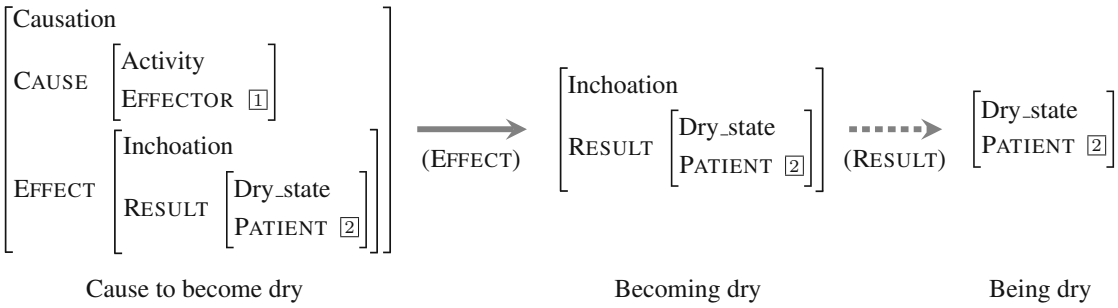

Fig. 6.6 Frame-based event structure decomposition of causative and inchoative *dry*

the frame itself. Doing this means to move from the plain role frames used in FrameNet to more complex frame structures which allow the embedding of one frame in another. Term-based decompositional representations of the kind shown in (6) offer a first blueprint of how to proceed. For example, the primitive one-place state predicate **dry** can be reinterpreted as a basic state frame Dry_state with a role Patient, whose filler corresponds to the argument of the predicate; see the attribute-value matrix on the right of Fig. 6.6. The BECOME **dry**(y) term can be taken as an Inchoation frame whose attribute Result is filled by the Dry_state frame; see the matrix in the middle of the figure. Finally, the overall CAUSE term of (6) corresponds to a frame Causation with attributes Cause and Effect, which are filled with the Activity and Inchoation subframes, respectively, as depicted on the left of Fig. 6.6. The resulting decompositional frames are related to each other by virtue of their inner structure. Compact frame names such as 'Cause_to_become_dry' can now be introduced as abbreviations for complex frame structures, or, on a more formal basis, as elements of a type hierarchy associated with complex attribute-value declarations.[19] The frame-specific roles of FrameNet, which have their purpose, e.g., in easing the annotation task, can be reintroduced as shortcuts for attribute paths of the decompositional frame structures. For example, the role Dryee can be defined as the concatenated path Effect|Result|Patient of the Cause_to_become_dry frame.[20]

The transformation of standard decompositional schemas into frame structures is only a first step in developing an elaborate frame semantics. Term-based decompositions like the ones in (6) are usually rather limited in representing information about, e.g., attributes of participants or other implicit components of a situation. Frames in the general sense of Barsalou (1992), or of Fillmore (1982) for that matter, are more expressive in this respect. As an example, consider again the representations for *dry* given in Fig. 6.6 and the respective FN 1.5 frames listed in Table 6.4. None of the frame structures in Fig. 6.6 captures the actual process the "patient" undergoes during drying. Unlike pure change of state verbs such as *break*, which are non-specific about how the resulting state is achieved,

[19] E.g., along the lines of Carpenter (1992).

[20] Introducing specific semantic roles this way is similar to defining them in terms of positions in decompositional structures as proposed by Van Valin and LaPolla (1997, Chap. 3).

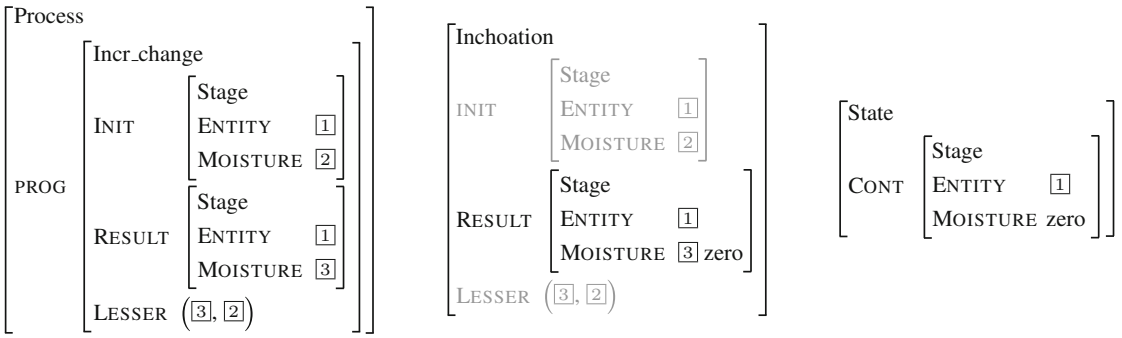

Fig. 6.7 Representation of (non-causative) atelic, telic, and stative *dry*

deadjectival *degree achievement* verbs (Dowty 1979) like *dry*, *darken*, and *cool* allow an atelic interpretation which profiles the change process without entailing the result denoted by the base adjective. The different readings can be triggered by temporal adverbials: *dry for an hour* means to get drier and drier within that hour without necessarily being dry afterwards, *dry in an hour* implies a resulting dryness.

The decompositional Becoming_dry frame of Fig. 6.6 is a plain change of state frame whose result state is dryness. Similarly, the definition of the corresponding FN 1.5 frame shown in Table 6.4 entails the resulting dryness of the undergoer. Both frames do not cover the situation where an entity gets drier without becoming dry.[21] As to the process of drying, the definition in Table 6.4 mentions the loss of moisture, which, however, has no consequences for the semantic content of the FrameNet frame. Decrease of moisture, or increase of dryness for that matter, is in fact the core characteristics of the process of drying. The general pattern behind this type of process is that an entity undergoes a change with respect to the value of one of its attributes, here, the degree of moisture or dryness. More precisely, the change in question is either an increase or a decrease of that value on an ordered scale.[22] An appropriate semantic representation of this situation type should therefore take into account the respective attribute of the undergoer and the ordering of its possible values. Figure 6.7 indicates how this can be achieved within a frame-based account. The basic component of these frames is the instantaneous "moisture stage" of an entity, which can be conceived of as a snap-shot of the entity having a certain degree of moisture.[23] Stages provide a natural way to model changes of attribute values. The atelic interpretation of *dry* can be analyzed as a process whose progression (PROG) consists of an ongoing incremental change between two stages of the undergoer of which the second has a lesser degree of moisture than the first. The

[21] Notice that this could lead to faulty inferences, given that the missing inchoative relation between Becoming_dry and Being_dry is added.

[22] See Kearns (2007) and Kennedy and Levin (2008) for detailed analyses of the relation between attributes, scales, and scalar change.

[23] Cf. Bittner and Donnelly (2004) and Sider (2001) on the stage view of objects.

corresponding frame structure on the left of Fig. 6.7 employs a relational constraint LESSER between moisture values. The telic, inchoative interpretation depicted in the middle of the Figure resembles the inchoative frame of Fig. 6.6.[24] The stative interpretation of *dry* is then represented by the situation type in which the stages of the entity in question are constant with respect to their degree of moisture, which is 'zero' in this case; see the frame on the right of Fig. 6.7.

At first glance, it might appear that the proposal described here leads to a multiplication of frames. This is true insofar as we think it important to keep track of the differences between processes and accomplishments in the frame representations of situation types. This distinction is relevant to the understanding of the syntax-semantics interface as well as for drawing correct inferences. If something is not necessarily dry after having dried for an hour then an automatic reasoning system should not come to a different conclusion. On the other hand, it is important to notice that the frame structures in Fig. 6.7 are not tailored for specific verbs but represent fairly general situation schemata. The only verb specific meaning components are the moisture attribute and its associated value scale, both of which are determined by the adjectival root of the verb. If we abstract from these components then the frame on the left of the figure is about situations where an entity undergoes a continuous change with respect to the value of one of its (scalar) attributes such that the value decreases on the scale in question. The situation type encoded by the frame in the middle of the figure differs in that the minimal value on the attribute scale is reached and the exact course of the change not specified. The event structure schemas of both frames are clearly relevant to other degree achievement verbs as well. Moreover, the two frames are systematically related to each other. Hence, if one wants to speak of frame multiplication at all, then it should be in the sense of a more thorough account of the combinatorial potential of elementary event structure components. Another objection could be that the above distinction between the process and the accomplishment interpretations of *dry* is not part of lexical semantics but should be modeled in terms of aspectual coercion or the like. A first reply is that at least the current FrameNet annotation would not allow such a "post processing" since *in* and *for* adverbials are both annotated as Duration. More crucial is the question of what to count as a frame evoking unit, especially from a cross-linguistic perspective. For example, the Australian aboriginal language Mparntwe Arrernte encodes the distinction between the process and the accomplishment interpretation of degree achievement verbs like *cool* by means of process and result affixes (Van Valin 2005, pp. 43f). If some languages encode Aktionsart operators as bound morphemes while others do not, the focus on word units as frame-bearing elements may run into serious problems when it comes to language comparison.[25]

[24]The shaded INIT and LESSER components are redundant if changes of state are always assumed to have an initial stage different from the result stage and if 'zero' is the minimal value of the degree of moisture scale.

[25]It remains to be seen whether the recent initiative of including frame bearing constructions into FrameNet (Fillmore et al. 2012) will be able to resolve these issues.

6.4 Case Study: Verbs of Cutting and Fragmentation

Verbs of cutting and fragmentation provide a good touchstone for lexical semantic representation and linking. They have been studied widely with respect to differences in their argument realization options and varying lexicalization patterns across languages (Guerssel et al. 1985, Mairal Usón and Faber 2002, Majid et al. 2007). Cut-verbs have also been discussed with respect to the controversial thesis of a manner/result complementarity in lexical encoding (Bohnemeyer 2007, Rappaport Hovav and Levin 2010).

The verb *cut* occurs in FN 1.5 as a lexical unit in the frames listed in Table 6.5. The table also shows a number of verb units associated with these frames. In the following, we are concerned with senses of *cut* that are related to affecting a physical entity by means of a sharp-edged object, resulting in incision and, possibly, separation or fragmentation. Senses of *cut* meeting this constraint occur in the frames Cutting, Removing, Experience_bodily_harm, and Cause_harm, which are marked bold face in Table 6.5.

There are several more senses of *cut*, but missing senses at an intermediate stage of the project are an inevitable consequence of FrameNet's frame-oriented working procedure. For as Fillmore (2007, pp. 139ff) points out, the frame-based exploration of word meanings "pays attention to paraphrase relation and postpones thorough treatment of polysemy structures." An obvious gap among the concrete, object affecting meanings of *cut* is the sense "trim or reduce in length of (grass, hair, etc.) by using a sharp implement" (Oxford Dictionary of English, 2nd ed.). In fact, FN 1.5 seems to have no frame for this scenario since *trim* and *mow* are not covered either. Another missing pattern is *cut a hole into something*.

6.4.1 Cutting and Other Ways of Separation

The core meaning of *cut* is represented by the Cutting frame introduced in Sect. 6.2.2.1 (Table 6.1). Somewhat surprisingly, FN 1.5 provides no annotated

Table 6.5 List of all frames in FN 1.5 with verb unit *cut*

Cause_change_of_position_on_a_scale	*add*, *curtail*, ***cut***, *enhance*, *decrease*, *increase*
Cause_harm	*bash*, *batter*, *bayonet*, *beat*, *boil*, *break*, ***cut***, *elbow*
Change_direction	***cut***, *swing*, *turn*, *veer*
Change_operational_state	*activate*, *boot*, ***cut***, *deactivate*, *turn on*, *turn off*
Cutting	*carve*, *chop*, *cube*, ***cut***, *dice*, *fillet*, *mince*, *pare*, *slice*
Experience_bodily_harm	*break*, *bruise*, *burn*, ***cut***, *graze*, *hit*, *hurt*, *injure*
Intentional_traversing	*ascend*, *climb*, ***cut***, *ford*, *traverse*
Removing	*clear*, ***cut***, *discard*, *disgorge*, *dust*, *empty*, *remove*, *shave*

Table 6.6 Lexical units of Cutting with FN 1.5 sense definitions

cut	divide into pieces with a knife or other sharp implement
slice	cut into slices
cube	cut (food) into small cubes
dice	cut (food) into small cubes
fillet	cut (fish or meat) into fillets
mince	cut up or shred (meat) into very small pieces
chop	cut with repeated sharp, heavy blows of an axe or knife
carve	cut into hard material, sometimes with a carving knife
pare	trim by cutting away the outer edges of

examples for the lexical unit *cut* of Cutting.[26] But the examples for *slice* given in (2) and those for *chop* in (7) do as well.

(7) a. *Chop* [the onions]$_{\text{Item}}$ [finely]$_{\text{Manner}}$.
b. [The animals]$_{\text{Item}}$ are always *chopped* [into small pieces]$_{\text{Pieces}}$

The definition of the frame Cutting presented in Table 6.1 is repeated in (8).

(8) An Agent cuts an Item into Pieces using an Instrument.

One might object that this definition just illustrates schematically a certain use of the verb *cut*. Instead of (8), one would probably expect a typical dictionary definition of *cut* like "divide something into pieces with a knife or other sharp implement," which is, in fact, the sense definition given for the lexical unit *cut* of the Cutting frame. However, the "definition" of a frame is only intended as an informal description that indicates the kind of scenario the frame is supposed to represent. The definition plays no formal role in the FrameNet architecture. That said, we can take (8) as a characterization of the Cutting frame. All lexical units of this frame (except *cut* itself) are described as specific types of cutting. Table 6.6 lists these units together with their FN 1.5 sense definitions. As with frame definitions, the sense definitions of lexical units play no formal role in the FrameNet architecture; they are useful indicators for the human users and, especially, for the annotators. The sense definitions in FrameNet are either taken from the Concise Oxford Dictionary, 10th Edition, or are written by FrameNet editors.

The units *slice* through *chop* conform to the frame definition (8). The first four of them, *slice*, *cube*, *dice*, and *fillet*, have zero-related nouns that characterize the (form of the) resulting pieces. Except for *dice*, this verbal incorporation of the Pieces element is explicitly marked in FN 1.5. The case of *mince* is similar but specifies the size of the resulting pieces, not their form. The definition given for *chop* does not

[26]This is even more surprising in view of the fact that some of the annotated example sentences associated with other verb units of the Cutting frame contain *cut* in the correct sense; witness (9).

mention 'into pieces', but this could be a flaw of the chosen dictionary definition.[27] By contrast, the sense definitions of *carve* and *pare* are not subsumed by (8). None of them indicates that something is cut into pieces.[28] The sense of *pare* that appears in the FN 1.5 examples shown in (9) can be paraphrased as "cut off the outer skin of something", typically used with fruits and vegetables.[29]

(9) a. *Pare* [the mangoes]$_{\text{Item}}$ and cut the flesh away from the pit lengthwise into long slices.
b. Thinly *pare* [the rind from 1 orange]$_{\text{Item}}$ and cut into narrow strips.

In (9), we have actually two distinct lexico-syntactic patterns of *pare*. The direct object of (9a) refers to the entity whose outer skin is cut off; in (9b), the outer skin is expressed by the direct object and the corresponding entity is expressed by the *from*-PP. Note that the FN 1.5 annotation of (9b) mistakenly combines the object NP and the PP to a single constituent. While (9a) could be classified as a "trimming by cutting" scenario, the type of situation expressed in (9b) falls under "cutting off a part from a whole". Neither of the situation types is covered by the Cutting frame as introduced in Table 6.1.

It is striking that neither *hack*, *hew*, *saw*, *snip*, nor *slash* are listed among the units of Cutting, for one easily finds corpus attestations of the pattern *hack/hew/saw/snip/slash sth (in)to pieces* and dictionary definitions typically describe these verbs (in one of their senses) as verbs of cutting. As mentioned before, FrameNet aims at a frame-wise processing of the lexical domain. Hence, one wonders whether these verbs are left out by accident or on purpose. The answer depends on which situation type the Cutting frame is supposed to represent. In view of (8), the situation in question is about cutting-related activities which result in the affected entity being in pieces. With *cut* and *chop* as units of the frame, there seems to be no reason not to include *hack*, *hew*, *saw*, etc. as well.

As mentioned above, definition (8) suggests that the affected item's being in pieces is an essential component of the Cutting frame. More evidence for this conclusion comes from the fact that Pieces is a core element of Cutting. Recall from Sect. 6.2.2.1 that core elements are "necessary to the central meaning of the frame". Hence, no Cutting without Pieces. Situations where someone cuts into an object, or at an object, without separating it are thus not represented by Cutting. But even if the cutting leads to pieces, the situation is not necessarily subsumed by the Cutting frame. Consider situations described by phrases such as *cut a branch off the tree*. Here, a piece is separated from a whole without the whole going to pieces. The definition of the Cutting frame and the lack of appropriate core elements imply that

[27] Consider, e.g., the following two Dictionary definitions for the relevant sense of *chop*: "cut (something) into pieces with repeated sharp blows of an axe or knife" (Oxford Dictionary of English, 2nd ed.); "to cut sth into pieces with a sharp tool such as a knife" (Oxford Advanced Learner's Dictionary).

[28] Note that there is a use of *carve*, as in *he carved the roast into slices*, that conforms to (8).

[29] Of course, only the *pare* clause of the coordination is relevant here.

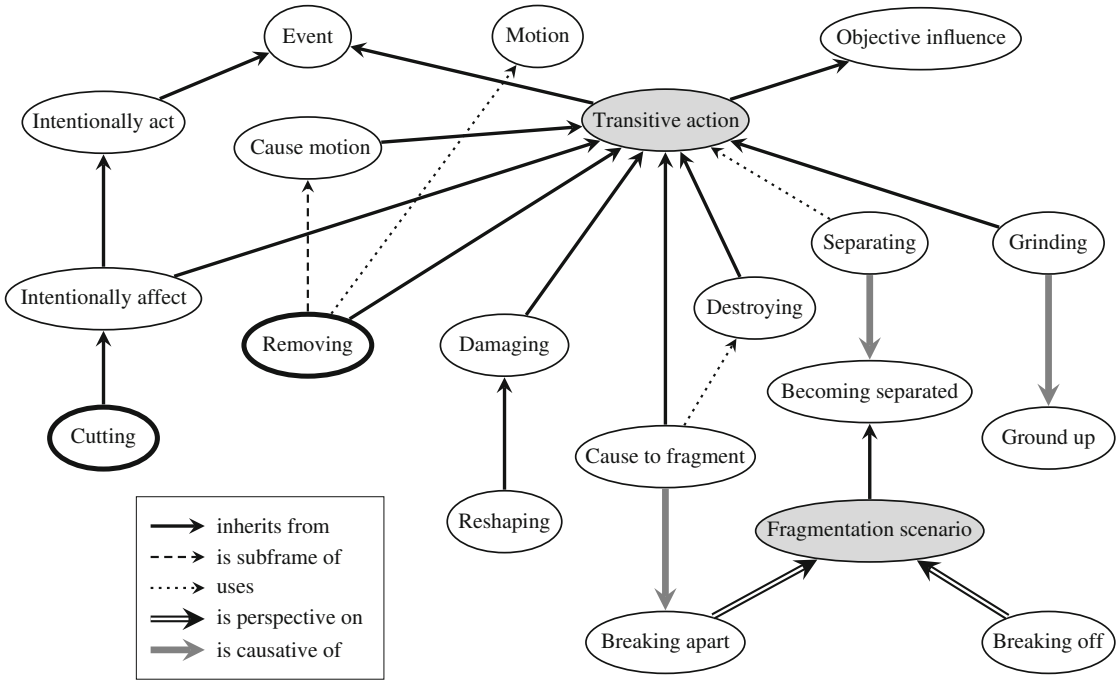

Fig. 6.8 Frames for *cut*, *split*, *break*, *rip*, *shred*, etc. and their interrelation in FN 1.5

the "cutting off" scenario is not within the scope of the Cutting frame (see also the discussion of the interpretation of *pare* in (9b) above).

The given characterization of the Cutting frame raises a number of questions: Should the frame be extended to cover "cutting off" scenarios as well? What about cutting events that result in an incision but do not lead to separation? In which way is Cutting related to other frames of separation and fragmentation? Several FN 1.5 frames are explicitly concerned with fragmentation and separation scenarios. Figure 6.8 gives an overview of these frames and shows how they are related to each other and to the frames Cutting and Removing, both of which have *cut* as a lexical unit. (Shaded nodes represent again non-lexical frames.) The definitions and lexical units of most of these frames are listed in Table 6.7 (with verbs to be discussed in the following in bold-face). Besides Cutting there are two other frames, Cause_to_fragment and Breaking_apart, that have Pieces as a core element. Pieces is bound to Parts in the 'is perspective on' relation between Breaking_apart and Fragmentation_scenario, and Parts is also a core element of the frames Separating and Becoming_separated. The FN 1.5 examples in (10) describe situations where some entity is separated or fragmented into parts or pieces.

(10) a. The young men *split* [the cattle]$_{\text{Whole}}$ [into two groups]$_{\text{Parts}}$ Separating
b. *Split* [the cake]$_{\text{Whole}}$ [in half]$_{\text{Parts}}$ horizontally Separating
c. [French flags]$_{\text{Whole\_patient}}$ were *ripped* [in half]$_{\text{Pieces}}$ Cause_to_fragment
d. *Break* [the carcass]$_{\text{Whole\_patient}}$ [into small pieces]$_{\text{Pieces}}$ Cause_to_fragment
e. *shredding* [the notes]$_{\text{Whole\_patient}}$ [into little pieces]$_{\text{Pieces}}$. Cause_to_fragment
f. [thinly]$_{\text{Manner}}$ *shred* [each half]$_{\text{Whole\_patient}}$, using a sharp knife. Cause_to_fragment

Table 6.7 Definitions of FN 1.5 frames related to fragmentation and separation, with selected verb units

Separating: These words refer to separating a [Whole] into [Parts], or separating one part from another. The separation is made by an [Agent] or [Cause] and may be made on the basis of some [Criterion].
bisect, *divide*, *partition*, *part*, *section*, *segment*, *segregate*, *separate*, *sever*, ***split***
Becoming_separated: A [Whole] separates into [Parts], or one part of a whole, called [Part_1], becomes separate from the remaining portion, [Part_2].
divide, *separate*, ***split***
Fragmentation_scenario: A [Whole] fragments or breaks into [Parts], or alternatively a part, [Part_1], breaks off from the rest of the item, called [Part_2].
(Non-lexical)
Breaking_off: A single [Subpart] breaks off from a [Whole].
break, *chip*, *snap*
Breaking_apart: A [Whole] breaks apart into [Pieces], resulting in the loss of the [Whole] (and in most cases, no piece that has a separate function).
break apart, *break down*, ***break***, *fragment*, *shatter*, *snap*, *splinter*
Cause_to_fragment: An [Agent] suddenly and often violently separates the [Whole_patient] into two or more smaller [Pieces], resulting in the [Whole_patient] no longer existing as such.
break apart, *break down*, *break up*, ***break***, *chip*, *cleave*, *dissect*, *dissolve*, *fracture*, *fragment*, *rend*, *rip up*, ***rip***, *rive*, *shatter*, *shiver*, ***shred***, *sliver*, *smash*, *snap*, *splinter*, ***split***, *take apart*, *tear up*, *tear*
Grinding: In this frame a [Grinder] or [Grinding_cause] causes an [Undergoer] to be broken into smaller pieces. A [Result] or [Goal] can be present.
chew, *crumble*, *crunch*, ***crush***, *flake*, *grate*, *grind*, *masticate*, *mill*, *pulverize*, ***shred***
Damaging: An [Agent] affects a [Patient] in such a way that the [Patient] (or some [Subregion] of the [Patient]) ends up in a non-canonical state. Often this non-canonical state is undesirable, ...
chip, *damage*, *deface*, *dent*, *key*, *nick*, *rend*, ***rip***, *sabotage*, *scrape*, *scratch*, *tear*, *vandalise*
Removing: An [Agent] causes a [Theme] to move away from a location, the [Source].
clear, *confiscate*, ***cut***, *discard*, *disgorge*, *drain*, *dust*, *eject*, *eliminate*, *empty*, *excise*, *expel*, *expurgate*, *extract*, *file*, *flush*, *prise*, *purge*, *remove*, *rinse*, ***rip***, *scrape*, *shave*, *snatch*, *strip*, *swipe*, *take*, *tear*, *unload*, *wash*, *withdraw*

g. [thinly]$_{\text{Result}}$ *shred* [each half]$_{\text{Undergoer}}$, using a sharp knife. Grinding
h. *crush* [them]$_{\text{Undergoer}}$ [to bits]$_{\text{Result}}$. Grinding

With the exception of (10a), the verb contexts in (10) are compatible with cut-verbs like *slice* and *chop*. However, generalizations about this similarity in syntagmatic patterning are not supported by the FN 1.5 frame-to-frame structure shown in Fig. 6.8. There is no general representation of the meaning component common to the described scenarios, that is, of the turning of something into pieces. Again, a decompositional analysis could help in this case. The frames

Cause_to_fragment, Grinding, and Cutting are not related to each other, except by their inheritance from Transitive_action, and Separating does not inherit from any frame at all. The Grinding frame, while mentioning "into smaller pieces" in its definition, has no Pieces element but uses the (non-core) Result element for this purpose; cf. example (10h).

The verb *shred* deserves special attention because it is a unit of the frames Grinding and Cause_to_fragment and it is defined as 'tear or cut into shreds' in both cases. There are even a number of sentences annotated by both frames, witness (10f) and (10g). Note that *thinly* is annotated as Manner in (10f) and as Result in (10g). The latter analysis seems adequate if the expression is taken to mean that it is the resulting shreds which are thin. However, FN 1.5 defines the Result element of Grinding as "the shape the Undergoer becomes" and this definition is difficult to reconcile with the foregoing interpretation of (10g) since it is not the Undergoer that becomes thin. This phenomenon is related to the *spurious resultatives* discussed by Washio (1997, pp. 17f), for which *cut the meat thick/thickly* and *tie the laces tight/tightly* are typical examples.[30] The crucial property of this pattern is that the "result" predicates are not applied to the entities denoted by the direct objects but to entities that are not overtly expressed, the slices in *cut the meat* and the knot in *tie the laces*. The lexical semantic constraints that underlie this construction clearly call for a frame semantic analysis that goes beyond plain role frames.

A further issue arises with the use of particles. The adverb *apart* occurs frequently with verbs of separation and fragmentation. The FN 1.5 examples in (11) contain annotated instances of *apart* used as a particle with the verbs *split* and *rip*.

(11) a. everything has been *split* [apart]$_{\text{Result}}$ by erosion. Separating
b. she *ripped* the thing [apart]$_{\text{Result}}$ with her sharp teeth. Cause_to_fragment
c. somebody got *ripped* [apart]$_{\text{Pieces}}$ by a diseased ferret Cause_to_fragment

The annotation of the element Pieces in (11c) seems misguided given the definition of Pieces as "[t]he fragments of the Whole_patient that result from the Agent's action". By comparison, the Result annotations in (11a) and (11b) are adequate since *apart* has the function of a resultative secondary predicate in these constructions.[31] The result of the separation or fragmentation is the object's being in pieces. A good part of the apparent problems with annotating Pieces and Result in FN 1.5 can be attributed to the fact that FrameNet has no means for representing the relationship between an activity and the resulting state of the affected object in a transparent way within a single frame. A different way to cope with particle verb constructions is to treat them as multi-word lexemes. There are a few particle verbs among the lexical units listed in Table 6.7, e.g., *break apart* and *rip up* in Cause_to_fragment.

[30]The restriction of the adjective to a postverbal position (**thick cut the meat*) does not seem to preclude the resultative interpretation of the preverbal adverb in (10g), but this point may need further investigation.

[31]See also Bolinger (1971, Chap. 6).

However, pursuing this strategy would lead to a proliferation of lexical units paired with a loss of generalization about the constructional behaviour of the base verbs.

It was mentioned above in passing that example (10a) is not compatible with *slice* and *chop*. The reason is that the described situation is not about separating a single physical entity into two or more parts (or pieces) but about dividing a collection of individual entities into subgroups. The Separating frame seems to cover both types of situations while Cause_to_fragment is apparently limited to the first situation type. However, FN 1.5 has no corresponding inheritance relationship between the two frames (see Fig. 6.8). The Separating frame extends Cause_to_fragment in another important aspect: the frame covers not only "split apart" scenarios but also "split off" scenarios[32]:

(12) a. the wind *split* [a bough]$_{\text{Part\_1}}$ [from a tree]$_{\text{Part\_2}}$ Separating
b. we *split* [our business]$_{\text{Part\_1}}$ [from Healthcare]$_{\text{Part\_2}}$ Separating

The dichotomy between "apart" and "off" scenarios has already been discussed above, where we noted that the Cutting frame does not cover "cutting off" scenarios. The Separating frame and, similarly, the frames Becoming_separated and Fragmentation_scenario resolve this dichotomy by providing core elements for both types of situations: Whole and Parts, as well as Part_1 and Part_2.[33] These two pairs of roles are disjoint alternatives in that they cannot occur together. Technically this is enforced in FrameNet by "frame element relations" such as 'exlcude' and 'require' (Ruppenhofer et al. 2010, pp. 21f), which are basically co-occurrence constraints on the set of core elements. A crucial question now is whether the alternatives ought to be accessible by perspectivization. In view of the fact the frame Fragmentation_scenario is perspectivized by Breaking_apart and Breaking_off, the answer seems to be positive. On the other hand, recall from Sect. 6.2 that perspectivization is based on the idea that a situation represented by a neutral, non-perspectivized frame is characterized by all of its perspective-taking frames as well. That is, all "split off" scenarios should be describable as "split apart" scenarios, and vice versa. This condition, however, is most likely untenable for examples such as (12a).

[32]Levin (1993) defines a separate split-verb class with members *break*, *cut*, *hack*, *kick*, *pull*, *rip*, *saw*, *split*, and *tear*, among others. The verbs of this class occur also in other classes such as the break-verbs, the cut-verbs, and the push/pull-verbs. When used as split-verbs, these verbs are said to manifest "an extended sense which might be paraphrased 'separating by V-ing', where 'V' is the basic meaning of the verb" (Levin 1993, pp. 166f). Among the alternation patterns associated with this class is the "*apart* reciprocal alternation" as exemplified by *I broke the twig off (of) the branch* vs. *I broke the twig and the branch apart*. Note that the 'apart' pattern of this alternation requires a collective NP as object. The sentences *I broke the twig apart* and *I cut the twig apart*, by contrast, would count as unrelated evidence for the resultative phrase patterns of the break-verb class and the cut-verb class, respectively. (Cf. Baker and Ruppenhofer (2002) for a comparison between FrameNet frames and Levin's verb classes.)

[33]The FN 1.5 definition of Separating shown in Table 6.7 is deficient in not explicitly mentioning Part_1 and Part_2.

Table 6.8 Definitions of harm frames in FN 1.5 with selected verb units

Cause_harm: The words in this frame describe situations in which an [Agent] or a [Cause] injures a [Victim]. The [Body_part] of the [Victim] which is most directly affected may also be mentioned in the place of the [Victim]. In such cases, the [Victim] is often indicated as a genitive modifier of the [Body_part] …
bash, *batter*, *bayonet*, *beat*, *belt*, *boil*, *break*, *bruise*, *burn*, *butt*, ***chop***, *claw*, *crush*, *cuff*, ***cut***, *elbow*, *electrocute*, *fracture*, ***gash***, *hammer*, *hit*, *hurt*, *injure*, *jab*, *kick*, *knee*, *knife*, *knock*, *lash*, *poison*, *slap*, ***slice***, *smack*, *smash*, *spear*, *stab*, *stone*, *strike*, *torture*, *wound*
Experience_bodily_harm: An [Experiencer] is involved in a bodily injury to a [Body_part]. (In some cases, no [Body_part] need be indicated.) Often an [Injuring_entity] on which the [Experiencer] injures themselves is mentioned.
abrade, *break*, *bruise*, *burn*, ***cut***, *graze*, *hit*, *hurt*, *injure*, *jam*, *pull*, *scrape*, *smack*, *sprain*, *strain*, *stub*, *sunburn*, *tear*, *twist*

A small number of cutting and fragmentation verbs show up as lexical units of the Removing frame (cf. Table 6.7):

(13) a. he had *ripped* [my wallpaper]$_{\text{Theme}}$ [off my wall]$_{\text{Source}}$ Removing
b. and *cut* [paintings]$_{\text{Theme}}$ [from their frames]$_{\text{Source}}$ Removing

Counting these verbs as units of Removing is not unproblematic since contexts like those in (13) are compatible with many other verbs of cutting and fragmentation (cf. (12a)). One might even come to the conclusion that all "off" scenarios can be seen as instances of Removing, which would position the frame high in the inheritance hierarchy.

6.4.2 Cuts and Other Injuries

Somewhat surprisingly, the only FN 1.5 attestations of cut-verbs in combination with *off* belong to the frame Cause_harm. Two of the examples are given in (14).

(14) a. the executioner should *cut* [[his]$_{\text{Victim}}$ head]$_{\text{Body\_part}}$ [off]$_{\text{Result}}$ Cause_harm
b. he *chopped* [[their]$_{\text{Victim}}$ tails]$_{\text{Body\_part}}$ [off]$_{\text{Result}}$ Cause_harm

The definitions and lexical units of Cause_harm and of the related frame Experience_bodily_harm are shown in Table 6.8 (with cut-verbs in bold-face).

There are good reasons to list the verb *cut* under Experience_bodily_harm because of its specific use in describing situations where you accidentally injure yourself on something sharp (*I cut my finger*, *I cut myself on a broken glass*). Treating cut-verbs like *chop*, *cut*, *gash*, and *slice* as units of the Cause_harm is, however, rather problematic. Nothing about the constructions in (14) is specific to

animate beings and their body parts. Cutting off a body part might cause harm to the affected being (if still alive) but this is not part of the meaning of *cut (off)*, in contrast, for instance, to *torture*. Consider example (15), which is annotated under Cause_harm for *cut* and *slice*.

(15) They scalped old men and women, beheaded others, slit throats, *cut* [out]$_{\text{Result}}$ tongues, *sliced* [off]$_{\text{Result}}$ ears, and hacked off limbs.

In view of the last clause of (15), it would be consistent to have *hack* in Cause_harm, too. And by a similar argument many other verbs would have to be added as well, including, e.g., *rip*, for tongues can be ripped out and ears can be ripped off and it is probably not difficult to find corpus examples that describe such scenarios.

As discussed above, cutting does not necessarily lead to separation but can result in an incision, or cut for that matter. This type of result, if describable as a damage or wound, seems more in line with the meaning of the Cause_harm frame. We take this as a further argument for a more elaborate frame representation that makes explicit the activities and results involved in the described situations.

6.4.3 Sketch of Reanalysis

As in the case studies presented in earlier sections, the issues we have identified in the domain of cutting and fragmentation verbs fall basically into two categories. On the one hand, there are deficiencies which could be resolved more or less easily within the present set-up of FrameNet. Issues such as the inappropriate inclusion of *pare* in the Cutting frame (cf. Table 6.6) can be simply settled by removing this unit from the frame. Straightening out the frame-to-frame structure shown in Fig. 6.8 is more demanding. This means to clarify, among many other things, how the frame Cause_to_fragment relates to the frames Separating and Fragmentation_scenario and how the distinction between "apart" and "off" scenarios cuts across the various frames discussed. Under the proposal put forward in this article, such a clarification is driven by event structure analysis, which leads to questions like the following: Which of the represented situations types have a causative structure? Which contain an activity or a change of state component? Which types of activities and results should be distinguished in the frame representations? These decisions should be empirically grounded. One such basis is given by FrameNet's annotated sentences, on which the existing frame structure is based in the first place. In addition, explicit Aktionsart tests can be employed such as the insertion of adverbials and appropriate semantic paraphrases and implications (cf. Van Valin 2005, Chap. 2).

The identification of the relevant types of activities and results has to cope with the problem of keeping the right level of granularity. Consider again the distinction between "apart" and "off" scenarios. The "apart" construction, if used with a non-collective noun, implies that the denoted undergoer looses its integrity,

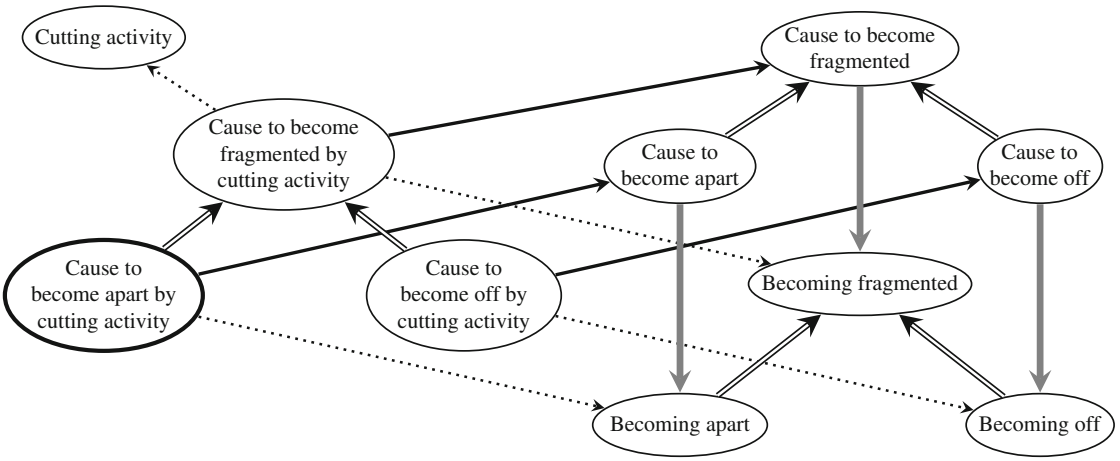

Fig. 6.9 Partial sketch of a frame system for fragmentation scenarios based on event decomposition

while the "off" case has no such implication. There are also clear differences on the morphosyntactic side between the result phrases involved. That is, the distinction in question captures certain regularities of the syntax-semantics interface. Moreover, some verbs can only be used, or have a strong tendency to be used, for one kind of fragmentation scenario but not for the other. For instance, *chip* is almost exclusively used for "off" scenarios while *shatter* is restricted to "apart" scenarios. In sum, there are good reasons to have the "apart"/"off" distinction represented in the domain of frames for fragmentation scenarios.

Suppose that, in addition to the fragmentation frame with its two perspectives,[34] we have accepted a frame for cutting activities. Then, if we allow fragmentation events to be caused, and caused fragmentations to be brought about by cutting activities, the frame system shown in Fig. 6.9 arises. For ease of exposition, the frames are described verbally; their actual decompositional structure is similar to the ones shown in Fig. 6.6. The Cutting frame of FN 1.5 corresponds to the frame on the lower left of the figure. Note that there is now a frame for the *cut/saw/chop off* examples, which is systematically related to the more general "Cause to become off" frame. Note also that there is no causative/inchoative structure for the fragmentation by cutting frames. This fact can be attributed to the additional activity involved.

While this simple example illustrates that frame inheritance can indeed give rise to generalizations about the syntax-semantics interface, it also indicates that the actual burden seem to lie on the identification of appropriate perspective-taking frames. Needless to say that the reanalysis presented in Fig. 6.9 covers only a portion of the frame structure of Fig. 6.8 and that many problems will still have to be solved concerning the precise form of the decompositional frame structures.

[34]For simplicity, we stick to FrameNet's view that "apart" and "off" scenarios are perspectives of fragmentation scenarios, in spite of the problems mentioned in Sect. 6.4.1.

6.5 Conclusion

As stated in the introduction and later in Sect. 6.2.3, it is Fillmore's vision that Frame Semantics as implemented in FrameNet can give rise to linking generalizations if abstract frames for movement, action, change, etc., and appropriate frame-to-frame relations such as inheritance and causation are added in a systematic way. The case studies presented in this article have shown that the FrameNet approach is faced with serious problems in coming up with a consistent and systematic relational system of frames of different degrees of abstraction. As a practical problem, the present set-up of FrameNet with its lexeme-oriented and example-driven definitions of narrow-domain frames is prone to inconsistencies that could hinder the systematic addition of more abstract frames. While a large-scale lexicon building and annotation project is probably not possible without making compromises concerning the depth of modeling, it is important that such compromises, shortcuts and the like are based on a clear vision of how the ideal solution should look like. Otherwise the project's set-up will be entangled in a web of ad-hoc decisions that could hinder if not inhibit the successive improvement and extension of the architecture, with the effect that the linguistically central goal of deriving linking generalizations remains out of reach. It is difficult to build a system of abstract frames on purely empirical grounds, i.e. from the bottom up. The task of building a general account of semantic frames requires a theoretically motivated theory of frame structure in addition to the empirical data. In other words, it is necessary to proceed both from the top down and from the bottom up. To this end, we proposed that a system of decompositional frames which allows the transparent representation of subcomponents of events and of attributes of participants could be an important step toward solving these problems. Such a system could provide an excellent basis for developing an empirically grounded theory of the syntax-semantics interface that combines FrameNet's strong reliance on extensive corpus analysis with typologically motivated insights into lexical semantic classes and their linking properties.

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