Circumstances and Perspective: The Logic of Argument Structure

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Abstract. Past research on *frames* has been hopelessly misguided. In this article, Mark will enlighten you.

1. Introduction

> The fox knows many things but the hedgehog knows one big thing.
>
> Archilochus
> cited by Isaiah Berlin
> Berlin (1997, "The Hedgehog and the Fox")

The last couple of decades have seen substantial progress in the study of lexical semantics, particularly in contributing to the understanding of how lexical semantic properties interact with syntactic properties, but many open questions await resolution before a consensus of what a theory of lexical semantics looks like is acheived. Two properties of word meanings contribute to the difficulty of the problem.

One is the **openness** of word meanings. The variety of word meanings is the variety of human experience. Consider defining words such as *ricochet*, *barber*, *alimony*, *seminal*, *amputate*, and *brittle*. One needs to make reference to diverse practices, processes, and objects in the social and phyisical world: the impingement of one object against another, grooming and hair, marriage and divorce, discourse about concepts and theories, and events of breaking. Before this seemingly endless diversity, semanticists have in the past stopped short, excluding it from the semantic enterprise, and attempting to draw a line between a small linguistically significant set of concepts and the openness of the lexicon.

The other problem is the closely related problem of the **richness** of word meanings. Words are hard to define, not so much because they invoke fine content specific distinctions, but because they invoke vast amounts of background information. The concept of buying presupposes the complex social fact of a commercial event. The concept of alimony presupposes the complex social fact of divorce, which in turn presupposes the complex social fact of marriage. Richness, too, has inspired semanticists simply to stop, to draw a line, saying the exact definition of such and such a concept does not matter for theoretical purposes.

Both problems have largely been ignored in lexical semantics in favor of focusing on a small inventory of concepts. One research program of this sort is offered in Lakoff (1972), in commenting on the lexical decomposition hypothesis in Generative Semantics.

> "In the analyses offered above, certain predicates keep recurring: CAUSE, COME ABOUT, SAY, GOOD, BAD, BELIEVE, INTEND, RESPONSIBLE FOR, etc. These are all sentential operators ... It seems clear that we would want these, or predicates like these, to function as atomic predicates in natural logic. Since these keep recurring in our analyses, it is quite possible that under the lexical decomposition hypothesis the list would end somewhere... verbs like *kick* and *scrub* could be ruled out as sentential operators since they could be analyzed in terms of already existing operators, as in [Sam caused the door to come to be open by kicking it] or [Sam caused the floor to come to be clean by scrubbing it]. This seems to me to be an important claim. Kicking and scrubbing are two out of a potentially infinite number of human activities. *Since the number of potential human activities and states is unlimited, natural logic will have to provide an open-ended number of atomic predicates corresponding to these states and activities. Hopefully, this can be limited to atomic predicates that do not take sentential complements.*"

The idea that the inventory of sentential operators must be closed is an important claim. In one form or another it has continued to play an important role in lexical semantics long after the particular syntactic implementation of lexical decomposition that Lakoff was working with has been abandoned. Dowty (1979) emphasizes this point, citing the above passage, while disagreeing as to whether ALL sentential operators form a closed class. But note that neither version of lexical decomposition inescapably leads to the conclusion that lexical semantics should focus exclusively on those concepts.

Another line of reasoning goes something like this. Linguists care only about two aspects of lexical semantics, those concepts which are universal and those which have syntactic consequences. This leads via the usual learnability and poverty of the stimulus arguments to the idea that there must be a small set of primitive concepts of theoretical importance to lexical semantics. Thus, while rejecting Fodor's finite language of the mind arguments, Jackendoff (1983; 1988; 1990) does assume a linguistically relevant level of **lexical conceptual structure** (LCS), which provides a limited inventory of concepts that constitute the interface to syntax. On the other side LCS is also linked to various other cognitive modules. The problem of dealing with a rich and open system of concepts is to be addressed there.

Within the last decade a somewhat different trend has emerged in lexical semantics. Borrowing a term from biologist Stuart Kauffman (2000), we can call these theories **constructivist**. A constructivist theory of biology has a broad conception of what a possible biological system is and takes as its subject matter the exploration of what the organizing properties of such systems are. Emphasis shifts from a search for primitives to a search for the necessary relations among primitive, whatever they may be. At the molecular level, this means constructing a set of axioms defining the organizing conditions for "metabolic" cycles which support replication, in effect constructing alternative biologies. A constructivist theory of lexical semantics would embrace a large open inventory of possible concepts and take as its subject matter the study of how possible concept systems may be organized, both as to paradigmatic and syntagmatic relations. The invention of alternative lexical semantic systems is of course a possibility, but is probably not very urgent. At the molecular level, life on earth is startlingly uniform; thus the study of general constraints on biological systems may require some invention. Languages at the lexical level do not suffer from this problem. The variety of concepts and morphosemantic processes in the world's languages seems quite sufficient to fuel the search for systemic properties.

Two fairly substantial efforts that might be called constructivist can be pointed to. First there is Pusteyovsky's Generative Lexicon (1995). One of Pusteyovsky's central concerns is the proliferation of word senses. He argues that a listing approach to polysemy is doomed and that what is required is a "generative" lexicon, which can allow single meanings to take on new senses productively in combination with other meanings. To this end (and others) he proposes a fairly complex system of semantic tiers, independent structural systems. At the top level we have argument structure, event structure, and qualia. Event structure and argument structure are literally hierarchically organized structures. Within qualia there is a further structural division into formal, telic, constitutive, and agentive. What is most significant in the present context is that the account is principally structural. The architecture is organized to tackle the problem of what happens when meanings combine. Pusteyovsky provides noun meanings, for example, with various qualia **hooks** (to use a metaphor from software engineering) which provide the information for sense transfer in the appropriate contexts. It is the qualia structure of the noun *book* that allows it to represent a physical object in some contexts and a container of information in others. Moreover, along with this structure, Pusteyovsky has no compunctions about providing information that other linguists might consign to the encyclopedia or to another cognitive module. The semantic representation of the noun *book*, for example, contains the information that books are readable. Reduction to a set of primitives, if it is in the program at all, is definitely on the back burner. The object of study is systemic properties of how meanings combine, generating senses, and there is no pressure toward a small set of concepts.

A second example of a very different kind is Levin (1993). The single most salient impression one derives from perusing this extensive study of English verb classes and English verb alternations is the richness of the concepts required to describe the data. Concepts required include putting, change of possession, removal, sending and carrying, force exertion, creation, destruction, learning, keeping, throwing, and impingement (contact by impact), to name just a small subset. For each concept, there is a class of related verbs, and in each case the relevance of the concept to syntax is established by presenting valence alternations sensitive to it. While this work is not inconsistent with an account by semantic primitives, the set of primitives required has clearly grown, and the move to an open set of concepts seems much more available. Most importantly, it is clear that the concepts required for making significant generalizations are not all sententail operators. Even if we stick to the program of accounting for what's relevant to syntax, a somewhat large inventory of concepts is required. This observation is not trivial for a reductionist program. As long as the set of primitives is dedicated to a modest well-defined list, like the Lakoffian sentential operators, things look quite coherent. But as the inventory is opened, the question arises, why this set of concepts and no more? How do we know we are finished? Hence the classic dilemma of deep case theory and thematic relations (Fillmore, 1968; Gruber, 1976), with its endlessly varying inventory of semantic roles. On the other hand, as the inventory of concepts opens up, the emphasis shifts from asking what concepts are there to asking what properties of concepts determine their linguistic realizations. How can concepts be taxonomized and related? What hooks do concepts have?

Until recently, talk about using an open set of concepts in lexical semantic theory did not seem very helpful. In the limit we have one concept per word. If we have one concept per word, how do we then talk about relatedness of concepts? If not, what proposal is there for a large open set of concepts that stops short of that?

We now have a concrete and detailed proposal of the required sort in the form of Framenet (Fillmore and Atkins, 1994; Baker et al., 1998; Fillmore and Atkins, 1998; Baker and Fillmore, 2001; Boas, 2001; Boas, 2002; Chang et al., 2002a; Chang et al., 2002b), a corpus-based lexical database annotating lexical targets for senses, frames (circumstances), and frame elements (circumstantial participants).

Framenet is based on Fillmorian concept of a frame (Fillmore, 1976; Fillmore, 1977; Fillmore, 1982), The essential intuition embodied in that work is that a frame embodies a small semantic paradigm, a set of words that describe *roughly* the same circumstances, but also function to express some contrasts local to the frame. The first example we will discuss in detail will be the *self-motion* frame, which includes verbs like *walk, jog, lope, lumber, march, mince, saunter, scamper*, and *scramble.* contrasting on a manner of motion feature.

Let us begin our discussion of frames by examining a few examples of frames from the current version FrameNet (2000), together with a brief description and a set of associated words.

1. to be filled in from FN2

The first thing that strikes one about this list is its open nature. No particular set of primitives has been assumed. A data-oriented approach has led to a proliferation of heterogeneous concepts. Small semantic neighborhoods have been selected. Yet in each case there is at least one core motivation for a frame: however small the semantic neighborhood, there is a set of words that elaborates it. The first key idea associated with Framenet is that each frame is associated with a specific kind situation, where the kinds of situations are as varied as human needs and goals, and each situation is in turn associated with a set of words. Working with this methodology, the set of concepts (frames) needed for a particular language is not infinite, but it is probably on the order of several thousand.

We will discuss the notion of a frame further in the next section. Here we evaluate some brief consequences of this proposal as it relates to a constructivist theory of lexical semantics.

Frames provide an answer to the problems of richness and openness of word meanings. The claim is that, with all the variety of word meanings, words tend to cluster into small neighborhoods of codefinability. There may be no generally useful notion of "semantic distance". We may not have an account of how closely the notion of impingement is related to the notion of surprise; but we can identify semantic kinship relations like hyponymy, antonymy, and logical converse. Words bearing these relations will be in the same or in closely related frames. Locally there is a notion of semantic distance. At the same time this is a system with a set of primitives; it is just a large and open set (open in the sense that it may be different the next language over, or a year later in the same language). There is no issue about what principle determines that the enumeration of the set of primitives is "finished". A primitive is simply an "unreduced" concept related to a kind of experience in the world articulably different from the other unreduced concepts. The problem of richness is now reduced to the problem of defining those primitives. Or to turn this around, the system makes a claim: Understanding a self motion verb means understanding what self motion is, and some parameters by which it can vary.

We can be certain that the set of frames will vary from language to language, because the idea of frames centers around the phenomenon of a set of words clustered around a kind of situation in the world, and languages differ in where they elaborate such sets. For example, where English has a rich set of verbs describing manners of walking (*stroll*, *amble*, *saunter*, *limp*), Japanese uses one verb (*aruku*). Arguably, English has a walking frame and Japanese does not. Japanese uses different verbs to describe the wearing and putting on of different kinds of clothing. The parameters are the body part the clothing is worn and the manner of fit. English is limited to a simple wearing relation expressed by wear/don/put on. Arguably, Japanese has a manner-of-clothing fit frame where English does not. If one of the theoretical goals is to provide a basis for comparing distinct systems, and there are no more primitives, how are these different concept sets to be compared?

The natural answer here is to assume that frames come with degrees of specificity: There is a hierarchy of frames. There is a *self-motion* frame for circumstances of agentive motion and a specialization of it called the *walking* frame, and verbs like *walk* and *saunter* may be said to belong to both.[1] When we speak of **the** frame of a verb, we are merely referring to the most specific frame. On this assumption there is a single frame *self-motion* shared by both Japanese and English, and a simple description of how English differs, through a specialization of that frame. For wearing, there needs to be a frame for *manner of clothing fit* in Japanese, in which the body-part is a frame element, where English has a simple frame for the wearing relation. Manner of clothing fit is a specialization of wearing. One might object to the existence of a wearing frame in English because the vocabulary for the clothing relation is not very elaborated. The justification for the frame is simply that there is no natural superordinate frame for the clothing relation. Rather than introduce some very abstract frame such as *state* and assimilate *wear* to that, the methodology of frames is to posit a fairly concrete relation with an impoverished lexical set. We end up with an account that lets us describe the contrast between English and Japanese simply: Japanese has elaborated a set of distinctions to cover a certain portion of the semantic terrain and English has not.

[1] The situation is somewhat more complicated because English has a general pattern of manner of motion verbs. This is described in more detail in Section 3.

Thus, along with Framenet, we assume that a theory of frames will include a set of taxonomic relations between frames. What those relations give us is a notion of a semantic landscape.

It seems to me this very simple property of frames provides a powerful argument for exploring the idea. Having defined a notion of semantic landscape, we can now go about examining how different languages differ in lexicalizing the same portion of the landscape.

This leads to the central concern of this paper. We have argued that lexical semantic description benefits from a large open class of concepts. But languages have limited means of realizing concepts in single clauses.[2] Typically participants in the circumstances described by a frame have to be realized as arguments, and arguments are marked with closed class devices, case-marking, head-marking, adpositions. A central question then becomes: How does the rich variety of frames get realized by a limited inventory of means?

Implicit in asking this question is the assumption of a *semantic theory of valence.*

For a number of years now the dominant assumption within lexical semantics has been that the semantics of heads *largely* determines its valence; there has been some equivocation on the exact import of *largely*, for example, as to whether the choice of a preposition like *on* as a marker for the oblique of a verb like *dote* has much semantic import; yet there seems little doubt that the semantics of a predicate at least strongly constrains its valence, narrowing the possible valences down to a very few.

The central subject of this paper is to explore the architecture of a lexical semantic theory which assumes that valences are semantically constrained, or even that they carry semantics of their own (Goldberg, 1995), and provides an explicit account of their relationship with frames. The idea is that frames — which we call circumstantial frames — encode a description of a particular class of situations with a particular set of participants and parameters which those situations may vary. But they do not directly encode any information about how a concept is realized. Though circumstance frames vary from language to language, the

[2] The general concept here is really more like "realizing a concept in a single maximal projection", rather than a single clause, because the same issue arises for nouns, verbs, and adjectives.

variations may be located within a shallow hierarchy, so circumstance frames provide the descriptive means to compare concepts cross-linguistically.

On the other side we will have a set of argument structures with semantics of their own – encoded in a set of what we call **argument frames**. Argument frames are frames too in the sense that they identify classes of situations in the world, but they will be specifically tied to the possible valences of a particular language.

So the question of how an open class of concepts is realized by a limited set of devices now becomes: How are circumstantial frames realized as argument frames?

There are two parts to this problem. First we find we need to characterize the notion of what a possible valence is. That is, given certain properties of concepts (their deep case roles, for example, on the deep case hypothesis of Fillmore (1968)), what valences can they be realized with? This component of a lexical semantic theory has been called a linking theory (Ostler, 1979). I take linking theory here to include an account not just of which arguments become nuclear terms but also an account of how obliques are marked. For a frame-based semantics the challenge is to discover what properties of a rich inventory of concepts determine their valence properties.

Second, and perhaps more importantly, we find that concepts are realized in more than one way. We need an account of indeterminacy in valence realization, and we need an account of sense transfer.

Consider the case of verbs describing commercial events(Fillmore, 1977).[3]

(1) a. John bought it from Mary.
    b. Mary sold it to John.
    c. John spent $20 for it (*from Mary).

All three verbs in these examples, *buy, sell* and *spend* describe a situation in which some goods is bought for money. Three very different valence patterns are exhibited, with different participants chosen as subject and object, and different oblique markings. Additionally, there is a participant *seller* that the verb *spend* provides no way of syntactically realizing.

[3] Fillmore discussed commercial events originally as constituting a *scene*. This was a precursor of the idea of a frame.

Thus verbs differ in the *perspective* they take on a single scene, to use Fillmore's term. Even with a single verb, a single participant may take more than one realization:

(2) a. John spent $300 on that sweater,.
b. John spent $300 for that sweater.
c. John slapped at the fence with a stick.
d. John slapped the fence with a stick.
e. John pierced through the cushion with a pin.
f. John pierced the cushion with a pin.

The last two example are due to Gruber (1976). Most importantly, perhaps, a single verb may appear in a variety of valences while clearly linked to the same core concept:

(3) a. The stick hit the fence.
b. John hit the stick against the fence.
c. John hit the fence with the stick.
d. John hit the ball over the fence.

Sentences (a)-(c) share the idea that the stick moves into contact with the fence. In (d) some unspecified implement comes into contact with the ball propelling it over the fence. The concept of impingement is constant. We assume that all of these sentences need to be related, directly or indirectly, to a single *impingement* frame.

Finally the valence patterns that appear with one kind circumstances seem to sometimes be transferable to others:

(4) a. John broke the hammer against the vase.
b. John hit the hammer against the vase.
c. John sneezed the pepper off the table.
d. John rolled the ball off the table.

A circumstance of breaking seems to require one participant. There is a productive causative alternation in English that relates one participant verbs to two participant verbs with an actor and that actor seems to be present in (a), but a third participant has also entered the picture; the valence pattern that occurs with impingement verbs (as in (b)) shows up with the one-participant verb *break*. And the truth conditions seem to require an impingement as well. The hammer breaks as a result of hitting the vase. What has happened is that the concept of impinging and the concept and breaking seem to have become glued together. This is an important phenomenon for a open theory of frames because on the face of it the concepts of breaking and impingement ought to be disjoint. Moreover it seems that what is happening is language particular. Japanese has no way of realizing a translation of (4a) with a valence characteristic of impingement verbs.

If we look at these facts in terms of a theory of circumstance and argument structure, one important question becomes: Which is responsible for the glueing together of these concepts, circumstance or argument structure? The answer we will propose is that in order to account for the limited productivity of such glued-together concepts, we need to appeal to both.

The examples in (4c) and (4d) are the sort discussed in Goldberg (1995). The resemblance with (a) and (b) is striking. A one-participant verb *sneeze* is given an extended meaning in which new participants enter the picture, something moved and a location moved to. Goldberg proposes a well-worked out system attempting to answer the question of how concepts can be "glued" together in examples like this. She argues that valence patterns have an independent status of their own; they are "constructions" which can be combined with core verb meanings to yield extended senses with new participant structure. The proposal pursued here, separating argument structures from circumstances, is in the same spirit, because it gives argument structures independent status, allowing them to combine with a variety of circumstances. But we will argue that the realization of circumstances in a core verb meaning — argument projection — needs to be distinguished from extensions of that concept to different participant structures. In particualr argument projection is governed by something we will call **the entailment principle**, essentially guaranteeing that the semantics of the argument structure is entailed by the semantics of circumstances. Sense transfer, on the other hand, is not limited this way.

We will argue that (4a) should be analyzed as an instance of a produuctive sense transfer but (4c) should not, the chief evidence being that the sense transfer in (4a) is productive over a circumstantially definable class of verbs (change of shape verbs), while the sense transfer in (4c) is not.

In sum the theory proposed here will have four theoretical components:

1. A theory of circumstances
2. A theory of argument projection (how circumstances are mapped to argument structures).
3. A theory of linking (how argument structures are mapped to syntax)
4. A theory of sense transfer

In the end what we will have is a constructivist theory. We embrace an open class of concepts and turn our attention to systemic properties of the concepts. What contrasts are made? What properties of concepts determine their linguistic realizations? How may concepts be related? How may they be glued together?

In the next few sections we will try to work these preliminary intutions out in some detail. The plan of the paper is as follows:

1. a brief introduction to circumstances and frames
2. Some examples illustrating how lexical meaning can be factored into circumstances and argument structure, using some familiar examples from the literature, commercial events, verbs of contact or impingement like *hit*, and verbs of change of shape like *break*.
3. A brief discussion of how argument structure is linked with valence. The theory of nuclear term realization is not novel and is largely for concreteness. What is more novel is that this component includes an account of the semantic compatibility of both argument and adjunct marking with heads.
4. A discussion of some examples of circumstance-preserving sense transfers, again with the verbs of impingement and change of shape.
5. a discussion of how non core arguments can be mapped to circumstantial participants, using the example of *for*-phrases.

2. Frames: Introductory Material

A few preliminary remarks are in order on the role of the notion frame as a building block for a theory of lexical semantics. Some of this discussion is a direct reprise of Fillmore (1976; 1982). Other parts reflect decisions imposed by the requirements of this particular formalization.

Word meanings are articulated against certain backgrounds. At times these backgrounds are quite complex. Fillmore (1982) cites the case of the noun *alimony*, which describes a sum of money which can only exist against the background of a pre-existing divorce. The noun *divorce* in turn describes an event which can only occur against the background of a pre-existing marriage. A verb like *ricochet* describes an event which can only happen against the background of one objection impinging forcefully on another.

Game terminology presents what is probably an even more extreme example. There is an interdependence between baseball concepts like *single, double, out, base* and *batter*, in the sense that one does not really understand the baseball sense of one of these terms without at least understanding the concepts behind them all. Thus a key idea here is that that frames are irreducible, but irreducible doesn't mean atomic. Certain irreducible concepts are nevertheless complex, containing parts in fixed relations, often with particular words denoting each part. They are co-defining. We call such a complex concept a **frame** and its parts **frame elements**.

To change domains and cite another of Fillmore's examples, the noun *hypotenuse* describes something which can only exist against the background of a right triangle. Using my terminology now rather than Fillmore's, the right triangle frame is the frame describing the **circumstances** in which the concept of a hypotenuse can be meaningful.

We now attempt to relate these circumstances to an argument structure. English possesses a basic lexical pattern for nouns expressing a relationship between a part (which we shall call an **instance**) and its inalienable possessor:

(5)
 a. **Instance** of **Possessor**
 b. hypotenuse of triangle ABC
 c. top of the hill, arm of the chair, leg of a triangle, left front door of a jeep

We will propose that the argument structure of such nouns of inalienable possession be captured by means of an **inalienable possession** argument frame which is defined for the roles **possessor** and **instance**.

We say that the noun's lexical predicate, *hypotenuse'*, is a projection of the **right triangle** circumstance frame into the **inalienable possession** argument frame, in which the **hypotenuse** participant is mapped to the **instance** role and the **triangle** participant is mapped to the **possessor** role. The schematic picture for the *hypotenuse* case is shown in (6):

(6)
$$\begin{bmatrix} \textit{right-triangle} & \\ \text{triangle} & \boxed{1} \\ \text{hypotenuse} & \boxed{2} \\ \text{side1} & \boxed{3} \\ \text{side2} & \boxed{4} \end{bmatrix} \xrightarrow{\begin{array}{c}\text{right}\\ \text{triangle}\\ \text{inalienable}\\ \text{possession}\end{array}} \begin{bmatrix} \textit{inalienable-possession} & \\ \text{rel} & \text{hypotenuse} \\ \text{instance} & \boxed{2} \\ \text{possessor} & \boxed{1} \end{bmatrix}$$

Thus there are two frames with some kind of mapping between them which determines that certain roles are linked. We call the relation linking a circumstance frame to an argument frame an **abstraction relation**. The semantics of this idea will be spelled out below, but the idea is roughly this: There are right triangle eventualities and inalienable possession eventualities in the world and the abstraction relation *right-triangle-inalienable-possession* is a total function from right triangle eventualities to inalienable possession eventualities. Since it is total it guarantees that each right triangle eventuality has an associated inalienable possession eventuality. Constraints on the relation will preserve the role identifications depicted in (6), namely:

$$\begin{array}{l} \text{triangle} \mapsto \text{possessor} \\ \text{hypotenuse} \mapsto \text{instance} \end{array}$$

As emphasized in the introduction, the goal of separating circumstance from argument structure is to facilitate cross-linguistic comparison. As an example, consider the English use of the preposition *in* to mark the relationship of an object in an image and the image, and compare to the Polish construction in the same context:

(7) a. the boy in the picture
b. # the boy on the picture
Ch lopiec na obrazie
boy on picture

As the English translation of the Polish suggests, the Polish description of the picture-object relation uses the preposition canonically associated with support and surface contact. It is not that Polish *na* means something special in this example. Rather, Polish emphasizes the fact that the picture is a surface, English the fact that it represents a space. A natural description of these facts in the current framework is that the circumstances are the same for both language, but that Polish uses an argument structure encoding surface contact and English an argument structure an argument structure encoding containment.

The remainder of this section will be devoted to sketching a formal approach that makes sense of this picture.

In ways to be spelled out in the pages to follow this accomplishes three basic pieces of linguistic description:

1. It provides the right entailments for the predicate *hypotenuse'*.

2. It determines what the semantic arguments of that predicate are (**instance** and **possessor**).

3. It determines the modification possibilities of *hypotenuse'*.

Argument frames are intended to embody semantic properties that predict syntactic properties such as valence. Conversely circumstance frames are intended to abstract away from those properties. One of those properties is syntactic category. The choice of the inalienable possession argument frame for lexicalization of a predicate will dictate that the predicate is realized as a noun. Another property is valence; the *possessor* role of inalienable possession can be marked the preposition *of*.

Summing up, an argument structure represents the language's perspective on a set of circumstances, one of a limited inventory of ways in which a word can be lexicalized so as to be syntactically realizable. The circumstances present a closely related set of conceptual materials to be lexicalized. Circumstances are prelinguistic but not preconceptual; they represent a particular way of classifying things. Thus a single situation in the world might belong to any number of circumstances. And different languages might choose different sets of circumstances in which to realize lexical sets.

One can rather naturally extend this way of thinking to the classic notion of a semantic field or a semantic paradigm. The words *cow, bull, steer* and *calf* can all be understood against the background of identifying cattle with different features. For such cases let us assume an argument frame **thing** for non-relational nouns, which provides only for a single **instance** role. We then describe a lexical predicate *bull'* as a projection of the **cattle** frame into **countable-concrete-thing** frame in which the **maturity** of the cow has been specified to be adult and the **sex** male. Note that in this case lexicalization requires not circumstance and argument frames, but also the specification of certain frame elements we will call **attributes**. the attributes of the *cattle* frame are **maturity** and **sex**. Schematically:

(8) $$\begin{bmatrix} \textit{cattle} & \\ \text{stock} & \boxed{1} \\ \text{sex} & \text{Male} \\ \text{maturity} & \text{Adult} \end{bmatrix} \overset{\substack{\text{cattle} \\ \text{thing}}}{\longrightarrow} \begin{bmatrix} \textit{countable-concrete-thing} & \\ \text{rel} & \text{bull} \\ \text{instance} & \boxed{1} \end{bmatrix}$$

The intention here is that **countable concrete thing** be a frame for concrete count nouns, adding the count/mass distinction to the list of grammatical properties determined by argument structure. Note that the cattle frame is not just limited to describing the paradigm *cow, bull, steer* and *calf*; it will also be responsible for another noun, *cattle*, which is neither in the paradigm, nor a count noun:

(9) $$\begin{bmatrix} \textit{cattle} & \\ \text{stock} & \boxed{1} \end{bmatrix} \overset{\substack{\text{cattle} \\ \text{thing}}}{\longrightarrow} \begin{bmatrix} \textit{mass-aggregate} & \\ \text{rel} & \text{cattle} \\ \text{instance} & \boxed{1} \end{bmatrix}$$

In a similar way the words *hot, warm, lukewarm* and *cool* can all be understood against the background of classifying the temperature relation, and will be realized by an argument frame that encodes the choice of an adjectival realization (with a role *degree*). The nouns *temperature* and *heat* will also be related to the frame, as will the verbs *warm*, *heat*, *cool*, and *freeze*, although the relation of the verbal predicates *warm* and *cool* to the frame will be captured by the sort of sense transfer relations discussed in Section 6.[4]

Clearly, the concept of frame does not reduce to the classic concept of an opposition set, as both the examples of *hypotenuse* and *cattle* show. There is no word opposed to *hypotenuse* in the right triangle frame, no word specifically selecting the non-hypotenuse legs of a right triangle, yet *hypotenuse* is still a clear concept. In a classic semantic domain theory like that of Trier, an opposition set with only one member is incoherent, whereas in frame theory there is no problem. Similarly, a single frame like the *cattle* frame can account for a classical paradigm set as well as other words not in the set.

The reason frames are more general than paradigms is that frames are defined through a set of real world circumstances with a particular set of participants. A word meaning selects a particular function within those circumstances, a particular side within the right triangle frame in the case of *hypotenuse*; thus a word can have a meaningful function independently of whether there are any words opposed to it in the frame.

Although frames cover both classic semantic paradigms and complex concepts, it is nevertheless the case that one can distinguish between these paradigm frames and complex-concept frames. When we say there is a set of words dedicated to describing temperature states (*warm*, *cool*, *hot*, *cold. lukewarm*, *freezing*) we are describing a set of words that describe one attribute and differ in a very fixed way we may describe in terms of oppositions on a scale. The baseball frame on the other hand has many more elements and the lexical items associated with it differ in abstracting out different parts of the complex frame such as the batter and the base. *Batter* and *base* do not contrast with one another in the

[4] *Heat* appears to be related to *hot* with the same inchoative semantic alternation that relates the adjectives *cool* and *warm* to the verb *cool* and *warm*, but there seems to be no productive morphological process involved; the suffix *en* seems to a moderately productive means of accomplishing the same sense transfer (*harden, sharpen, flatten*), and a still less productive means is the prefix *en* as in *enlarge*. See Bochner (1993) for a discussion of how to model such partial productivity in the lexicon, which might be applied to the case of *heat* and *hot*. We discuss partially productive sense transfers in Section 8.

same way as *warm* and *cool*. We might say *warm* and *cool* pick out a single element of a temperature state frame, the temperature scale, and locate different intervals on it, while *batter* and *base* pick out different elements of their frame.

In effect by calling these both frames we are claiming that these examples fall on a continuum. Very simple frames with few elements offer few lexicalization possibilities, and thus yield simple paradigmatic lexical sets. More complex frames offer other possibilities for opposition, but they are still frames with frame elements, and some of the words within them may still describe scalar oppositions. Thus, within the baseball frame we have line drives and bloopers, describing distinct ball arcs; within the commercial event, alongside frame element words like *buyer* and *seller* and *money*, we have *cheap* and *expensive* locating the amounts of money in trhe transaction on a scale. We argue below that words like *buy* and *sell* exemplify a different kind of opposition, selecting neither a frame element nor a point on a scale, but rather different ways of looking at the transfer of goods within the commercial event.

These examples are rather pat. There are many words for which the concept of background circumstances does not immediately come clear, the count noun *brick* for example, in the sense of the rectangular artifact used in building walls.[5] It is not obvious, if one casts about for a background frame, whether this belongs to something like a stone implement or a structural part frame, because there is no natural contrast set to which this word belongs.

In such cases we will say that a word has two circumstance frames, one classifying it with artifact circumstances, one with structural-part-of-whole circumstances.

[5] For another sense of *brick*, the mass noun sense designating the substance from which bricks are made, the circumstance of being a substance seems a likely candidate.

(10)
$$\begin{bmatrix} \textit{artifact} & \\ \text{instance} & \boxed{1} \\ \text{function} & \boxed{2} \end{bmatrix} \xrightarrow{\text{artifact countable}} \begin{bmatrix} \textit{countable-concrete-thing} & \\ \text{rel} & \text{brick} \\ \text{instance} & \boxed{1} \end{bmatrix}$$

$$\begin{bmatrix} \textit{part-of-whole} & \\ \text{part} & \boxed{1} \\ \text{whole} & \boxed{2} \end{bmatrix} \xrightarrow{\text{part of whole countable}} \begin{bmatrix} \textit{countable-concrete-thing} & \\ \text{rel} & \text{brick} \\ \text{instance} & \boxed{1} \end{bmatrix}$$

In effect this account says the word has two senses.

2.1. Logical Language

We require a descriptive framework for integrating frames with compositional semantics. A rather natural account pursued in Gawron (1983) becomes available if we make use of neo-Davidsonian event-semantics (Davidson, 1967; Davidson, 1980; Parsons, 1990). On a neo-Davidsonian account, we have, as the schematic semantics for *John bought the book on sale*:

$$\begin{aligned} \exists e[\text{buy}(e) \wedge &\, \textit{buyer}(e) = \text{j} \wedge \\ &\, \textit{goods}(e) = \text{b} \wedge \\ &\, \text{on-sale}(e)] \end{aligned}$$

We call e in the above representation the **lexical eventuality.** We call

$$\textit{buyer}(e) = \text{j}$$

a **role relation**. Many lexical roles are functional in the sense that they allow at most one filler per eventuality; but we allow nonfunctional roles in the exceptional case. When a role is functional we use = for the relation between a role and a filler; and when it is non-functional we use $\geq$.

We will assume a neo-Davidsonian event semantics throughout. Reference to event or eventualities has been fruitful in describing a number of semantic phenomena, including adverbial modification and aspect (Parsons, 1990; Pusteyovsky, 1991; Tenny, 1994, inter alia).

The lexical predicates for nouns will be eventuality predicates like those of verbs. The semantics for *John is a policeman* is, schematically:

$$\exists e[\text{policeman}(e) \wedge \mathit{instance}(e) = \text{john}\,)]$$

Thus there is no difficulty in representing a predicative use of a noun predicate. The semantics for *John is not a policeman* is just the negation of this formula:[6]

Borrowing the formal machinery of sorted logic,[7] we will assume that all predicates and role relations are **sorted**; that is, it is a property of a predicates and relations that in all models, for any given argument position, there is a certain sort of individuals for which that argument position is **defined** This set of individuals is called the **appropriateness** sort for that argument position of the predicate or relation. Predicates are true or false of entities that meet their sortal requirements; relations hold or do not hold for entities that meet the appropriateness conditions of their domain and range arguments. Both predicates and relations are undefined for entities outside those sortal requirements.

This is the basis for the treatment of semantic compatibility of modifiers and heads. When a role relation is predicated of an eventuality not in its appropriateness sort, the role relation is undefined:

(11) a. * John ate to school.
b. $\exists e[\text{eat}(e) \wedge \mathit{eater}(e) = \text{j} \wedge \mathit{goal}(e) = \text{school}\,]$

[6] To reduce clutter in non-predicative uses, when a noun phrase determiner has fixed the denotation of the noun phrase, we will omit reference to the eventuality:

$$\text{the } x \text{ policeman}(x)\ \exists e[\text{see}(e) \wedge \mathit{seer}(e) = \text{john} \wedge \mathit{seen}(e) = x\,]$$

$$\neg\exists e[\text{policeman}(e) \wedge \mathit{instance}(e) = \text{john}\,]$$

[7] Sorts can be viewed as an extension of a system of types. The most relevant development of typed/sorted logic can be found in the literature on the logic of typed feature structures(Carpenter, 1992; Smolka, 1992). In Carpenter, an explicit *appropriateness* function is defined for a partially ordered system of types. See Rounds (1997) for an excellent survey. Throughout we will switch back and forth between constraints in a sorted logic and typed-feature structures, because the two formalisms are very closely connected. Copestake, et al. (1988) apply typed feature structures to lexical semantics .

Eating eventualities do not have a goal role defined for them, so (11b) is undefined.

Sorts are simply sets of entities of a particular type. In this paper the only sorts assumed are individual level sorts, though one could imagine a need for sorts at all levels of a classical Montagovian theory of types. In the particular logic we adopt, we will make use of terms that denote sorts. For example, there will be a self-motion sort written **self-motion**. There will also be a self-motion predicate written self-motion (introduced in the previous section) true of self-motion eventualities. We use the typographical convention that sort names are in bold, role names italicized, and relation names are in roman typeface. For example, the sort declaration relevant to the preposition *to* in its goal sense would be:

(12) $\mathit{goal} : \textbf{directed-motion} \mapsto \textbf{place}$

The formula in (12) illustrates the kind of constraint we use use to define the domain and range sorts of a relation. The constraint in (12) says the the *goal* role is defined for directed motions and take places as its value. It can be true or false for entities in these sorts but it is undefined for entities outside the sort. Section 11 presents a model for sortally constrained relations.

Specification of a frame consists of specification of a frame relation (a sortal predicate), a set of participant relations defined on that frame, and possibly some axioms expressing relations between participant relations. We illustrate this with the example of a possession transfer circumstances (related to verbs like *give*, *take*, *receive*, *acquire*, *bequeath*, *loan*, and so on.

(13) (a) $\textbf{possession-transfer} \sqsubseteq \textbf{eventuality}$
(b) $\text{possession-transfer} : \textbf{possession-transfer} \mapsto \textbf{truth-values}$
(c) $\mathit{donor} : \textbf{possession-transfer} \mapsto \textbf{animate}$
(d) $\mathit{possession} : \textbf{possession-transfer} \mapsto \textbf{entity}$
(e) $\mathit{recipient} : \textbf{possession-transfer} \mapsto \textbf{animate}$

Part (a) declares a sort **possession-transfer** as a subsort of a very general **eventuality** sort; Part (b) declares a predicate possession-transfer typed for the sort **possession-transfer**; parts (c),(d), and (e) declare three roles *donor*, *possession*, and *recipient*, as functions with domain sorts possession transfer.[8]

We can represent this set of axioms as an attribute-value structure:

$$\begin{bmatrix} \textit{possession-transfer} & \\ \text{donor} & \textbf{animate} \\ & \\ \text{possession} & \textbf{entity} \\ & \\ \text{recipient} & \textbf{animate} \end{bmatrix}$$

We will use the attribute-value notation throughout, for its readability, but the reader should bear in mind that it is merely a shorthand. Throughout, our intention that the actual axiomatic development of a lexical system is captured using axioms like those in (13), with the essential primitive notion being constraints on partial functions and relations from sorts to sorts,

Although predicates and sorts are distinct, the logical language will in general provide provide one sort term for each **sortal** predicate, where a sortal predicate, like the frame predicate possession-transfer, is a predicate whose extension is restricted to its corresponding sort. Frame predicates and lexical predicates will both be **sortal** predicates. The extension of a sortal predicate is its appropriateness set. Thus for a sortal predicate like *possession-transfer*, the following is valid:

(14) $\neg\exists e \neg \text{possession-transfer}(e)$,

because only an appropriate e could falsify (14), but for all appropriate e,

$$\text{possession-transfer}(e)$$

is true.

[8] In general we will allow roles to be partial and non-functional. When a role is partial on its appropriateness sort, we write,

$$\textit{role} : \textbf{domain-sort} \mapsto (\textbf{rangesort})$$

using parentheses to signal optionality of the role. When it is non-functional we write

$$\textit{role} : \textbf{domain-sort} \mapsto \{\textbf{rangesort}\}$$

as mnemonic for the constraint that, in this case, a set of entities in the rangesort may stand in the defined relation to each entity in the domain sort.

The idea is that the only function of a sortal predicate is to define an array of roles. It is role relations that define a proposition that may be true or false. A sortal predicate, then, is not the sort of thing it makes sense to negate. [9]

We next define an argument structure for possession transfers. We will assume several are possible, depending on whether the donor or recipient is viewed as actor. We define the following core argument structure:

(15) ag-th-so : $\mathbf{ag\text{-}th\text{-}so} \mapsto \mathbf{truth\text{-}values}$
$actor : \mathbf{ag\text{-}th\text{-}so} \mapsto \mathbf{animate}$
$theme : \mathbf{ag\text{-}th\text{-}so} \mapsto \mathbf{entity}$
$source : \mathbf{ag\text{-}th\text{-}so} \mapsto \mathbf{animate}$

The roles actor, source and theme correspond to the usual thematic role/deep case notions of those names. The main empirical function of such role notions will be to constrain nuclear term realization in the linking theory. We call such a highly abstract argument structure a **basic argument structure.** Expressed attribute-value style, this is:

$$(16) \quad \begin{bmatrix} \textit{act-th-so} & \\ \text{actor} & \mathbf{animate} \\ \text{source} & \mathbf{animate} \\ \text{theme} & \mathbf{entity} \\ & \end{bmatrix}$$

We define the relation between a circumstance and argument frame via an *abstraction relation.* Here are the axioms for what we will call the acquisition realization, on which the recipient is actor:

---

[9] For example, there appears to be no linguistic need for the following formula:

$$\exists e[\neg \text{give}(e) \wedge actor(e) = \text{john}]$$

This formula, when defined, is always false, because it is only defined for walking eventualities, which are exactly the eventualities it can't be true of. Cases like

John didn't WALK; he RAN.

are cases of property focusing; the property in focus in the property of being the actor of a walking eventuality, as is demonstrated by the fact that such focal constructions are fine with changes of role:

John didn't WALK; he FELL.

(17) (a) acquisition : **possession-transfer** $\mapsto$ **ag-th-so**
(b) $\mathit{actor} \circ \text{acquisition} = \mathit{recipient}$
(c) $\mathit{theme} \circ \text{acquisition} = \mathit{possession}$
(d) $\mathit{source} \circ \text{acquisition} = \mathit{donor}$

First we define acquisition as a mapping from the sort **possession-transfer** to the sort **ag-th-so**, that is as a mapping from possession transfer eventualities to **ag-th-so** eventualities. The mapping is total; thus, each possession transfer is guaranteed to have an associated agent theme possessor-goal eventuality associated with it.

Note that constraints on the role realization have been stated using **composition** (defined in Section 11). For example, the composition of the *theme* relation with the acquisition relation written *theme*∘acquisition) gives us a relation with sort domain **possession-transfer** and sort range **animate**. The role equation in (17c) says this is the same relation (extensionally) as the *possession* relation. Thus the filler of the *possession* role in a possession transfer must be the same as the filler of the *theme* role in the associated **ag-th-so** eventuality.

We add one more role with a very special status to the acquisition argument frame. This is a *circumstance* role, whose function will be explained in our account of what we call circumstantial modification in Section 7. This is simply a "backpointer" from the argument frame to the circumstances:

$$\mathit{circ} :== \mathit{acquisition}^{-1}$$

This will be a general role on all argument frames;[10] it is simply the union of the inverse of all the argument projections. Among other things, this axiom guarantees that any eventuality in the range of acquisition must have a possession transfer filling its circumstance role.

Summing up these axioms AVM-style:

$$\begin{bmatrix} \mathit{possession\text{-}transfer} & \\ \text{donor} & \boxed{1} \\ \text{recipient} & \boxed{2} \\ \text{possession} & \boxed{3} \\ & \end{bmatrix} \xrightarrow{\text{acquisition}} \begin{bmatrix} \mathit{act\text{-}th\text{-}so} & \\ \text{actor} & \boxed{2} \\ \text{source} & \boxed{1} \\ \text{theme} & \boxed{3} \\ & \end{bmatrix}$$

[10] The exact semantics of ":==" is discussed in the next section

We may now define a verb like *get* in terms of function composition as well:

(18) $\text{get} = \text{possession-transfer} \circ \text{acquisition}^{-1}$

The acquisition^{-1} relation is the restricted inverse of acquisition (defined in Section 11). We explain this as follows. Call the set of agent-theme-source eventualities in the range of the acquisition relation *acquisitions*. The acquisition^{-1} relation is undefined for any eventuality that is not an acquisition. In effect we use the abstraction relation to define a new sort in the argument structure domain.[11]

The acquisition^{-1} relation maps a **ag-th-so** eventuality in the range of *acquisition* back to its associated possession transfer. Here we represent *get* as the composition of acquisition^{-1} with the possession-transfer predicate. Thus *get* is defined as a predicate true of agent-theme-source eventualities in the domain of acquisition^{-1}, such that for all x and y, the following condition holds:

$$\text{If } \text{acquisition}^{-1}(x)(y), \text{ then } \text{possession-transfer}(y)$$

This condition is actually redundant, since everything in the range of acquisition^{-1} is a possession-transfer, but it does no harm, and it will allow us to assume a general format for lexical predicate definitions. Lexical predicates will always be defined as compositions of an abstraction relation with a predicate.

For a verb like *give* we define the following core argument structure:

[11] For any function f

$$f : \sigma \longrightarrow \tau$$

that is not onto, there is a question about what to say about

$$f^{-1}(x)$$

for any $x \in \tau$ for which there is no y such that

$$f(y) = x$$

In Section 11, we define $f^{-1}(x)$ so that it is undefined for such an x. That is , f^{-1} is defined only for the image of f in τ. Thus $\text{goods-acquisition}^{-1}$ is defined only for those acquisitions related to a commercial event by goods-acquisition.

(19) $\text{ag-th-go} : \mathbf{ag\text{-}th\text{-}go} \mapsto \mathbf{truth\text{-}values}$
$\mathit{actor} : \mathbf{ag\text{-}th\text{-}go} \mapsto \mathbf{animate}$
$\mathit{theme} : \mathbf{ag\text{-}th\text{-}go} \mapsto \mathbf{entity}$
$\mathit{goal} : \mathbf{ag\text{-}th\text{-}go} \mapsto \mathbf{animate}$

Expressed attribute-value style, this is:

$$(20) \quad \begin{bmatrix} \mathit{act\text{-}th\text{-}go} & \\ \text{actor} & \mathbf{animate} \\ \text{goal} & \mathbf{animate} \\ \text{theme} & \mathbf{entity} \\ & \end{bmatrix}$$

We use an abstraction relation called giving on these circumstances:

(21) (a) $\text{giving} : \mathbf{possession\text{-}transfer} \mapsto \mathbf{ag\text{-}th\text{-}go}$
(b) $\mathit{actor} \circ \text{giving} = \mathit{donor}$
(c) $\mathit{theme} \circ \text{giving} = \mathit{possession}$
(d) $\mathit{goal} \circ \text{giving} = \mathit{recipient}$
(e) $\mathit{circ} :== \mathit{giving}^{-1}$

Summing up these participant projection axioms AVM-style:

$$\begin{bmatrix} \mathit{possession\text{-}transfer} & \\ \text{donor} & \boxed{1} \\ \text{recipient} & \boxed{2} \\ \text{possession} & \boxed{3} \\ & \end{bmatrix} \xrightarrow{\text{giving}} \begin{bmatrix} \mathit{act\text{-}th\text{-}go} & \\ \text{actor} & \boxed{1} \\ \text{goal} & \boxed{2} \\ \text{theme} & \boxed{3} \\ & \end{bmatrix}$$

We may now define a verb like *give* as

(22) $\text{give} = \text{possession-transfer} \circ \text{giving}^{-1}$

These axioms posit a number of function relations relating eventualities of various sorts. One of the kinds of work such relations can do is to account for entailment relations. We illustrate by sketching how the entailment from (23a) to (23b) is accounted for:

(23) a. John gave the book to Mary.
b. Mary received the book from John.

The predicate give is true of **ag-th-go** eventualities in the range of the abstraction relation giving. Now a **ag-th-go** eventuality x in the range of giving by definition has an associated possession transfer p, Both the giving and acquisition mappings are total, so p has an associated acquisition y of which receive is true. As a result, given the role mappings linking x and y to p, the entailment from (23a) to (23b) is accounted for.

The argument from (23b) to (23a) is symmetric, so the mutual entailment relation is accounted for. In general, as we will see, the account of role projection brings with it an account of the entailment relations between predicates related to the circumstance frame.

We have now sketched a pair of simple paths from circumstance to argument structure. The key role was played by the abstraction relations *acquisition* and *giving*. For the moment, we place a very simple restriction on abstraction relations: that they have as their domain sorts only circumstance sorts and that they have as their range sorts only argument structure sorts. We will further restrict them in Section 5, in the form of something called *the entailment principle*.

In Section 4.1, we will show that the relation between circumstances and argument structures can be more complex: Circumstances can be parasitic on other circumstances. There we will analyze *buy* as an acquisition and *sell* as a giving, by relating commercial events in two different ways to possession transfers.

One final issue we may address here is the relationship of the idea of participant projection as developed here to that of *inheritance*. Note that the two participant projection relations proposed here, *acquisition* and *donation*, might be interpreted as inheritance relations. On this view the possession transfer related to a giving is the same event as the giving; there are simply two predicates, *giving* and *possession-transfer*, and *giving* is true of a subset of possession transfers.

First, in terms of stating the role properties of predicates like *give* and *take*, this isn't more economical, because one still needs role projection axioms in order to say that *give* and *take* have different role assignments. Second, by making the abstraction relations *acquisition* and *donation* relations one-to-one and total, we automatically capture the entailment relation between *get* and *give*. Thus, for example, a giving eventuality g of which *give* is true entails the existence of a possession transfer p in the domain of the acquisition participant projection, and therefore there is also an associated acquisition a. Therefore, *get* must also be true of that acquisition a.

Of necessity an inheritance account of acquisitions and donations must capture the entailment relation with some relation other than the abstraction relation. By assumption the abstraction relation of an inheritance account is inheritance. But we don't want to say that the same possession transfer simultaneously projects as an acquisition and a donation, because if inheritance is the projection relation that means the givings and gettings are the same event, which predicts that *give* and *get* have the same valence realization possibilities, which loses one of the basic distinctions a semantic theory of valence is designed to make. So there is a simple argument of economy against making inheritance the abstraction relation in these cases. If we do that, the abstraction relation can't do double duty as a determiner of entailment properties. Putting this another way, we can go ahead and say that givings and acquisitions are possession transfers, but independently of that, to capture the entailment facts, we will still need non-identity relations between donations and acquisitions.

3. Self Motion

To illustrate some of the differences between circumstances and argument structure, we develop a simple example of circumstance and argument frames using a class of verbs much discussed in the literature, agentive intransitive motion verbs like *descend, dip, dive, bop, bustle*, and *crawl*. Following FrameNet, along with FrameNet and a number of authors(Talmy, 1985, particularly), we hypothesize (at least) two different kinds of motion predicates, those specifying information about the manner of motion, and those specifying information about motion path.

We begin with the definition of a general self-motion frame as given in FrameNet:

> A living being, the **Self-mover** moves under its own power. This motion may or may not be in a directed fashion, i.e. along what could be described as a path.[12]

We defer defining a formal representation of the frame until the next section.

Two distinct specializations of the self-motion frame will give us *manner-of-motion* and *path-shape*. We present a set of exemplifying verbs taken from FrameNet(Fillmore and Baker, 2000).

General Frame: Self-Motion

Frame: Manner-of-Motion

Manner verbs: bop.v, bustle.v, crawl.v, dart.v, dash.v, fly.v, hike.v, hobble.v, hop.v, jaunt.v, jog.v, lope.v, lumber.v, march.v, mince.v, saunter.v, scamper.v, scramble.v, shuffle.v, skip.v, slalom.v, slither.v, slog.v, sneak.v, sprint.v, stagger.v, step.v, stomp.v, stride.v, stroll.v, strut.v, stumble.v, swagger.v, swim.v, tiptoe.v, toddle.v, traipse.v, tramp.v, troop.v, trudge.v, trundle.v, waddle.v, wade.v, walk.v, wander.v

Frame: Path-shape burrow.v, descend, dip, dive, drop, edge, emerge, exit, extend(?), leave, meander, mount, plummet, reach, rise, skirt, slant, snake, swerve, swing, traverse, twist(?), undulate, veer, weave, wind, zigzag **Not so sure what to call them verbs**: drift, glide, sail, slide, slip **Vague motion verbs**: go, move, travel

The set of relevant frame elements is the following.

Frame Elements:

Self-Mover: *Pat* ran five miles. *The squirrel* hopped onto the branch.
Source: ran *out of the house*, ran *out*, ran *away*(source as implicit arg)

[12] In FrameNet, directedness of the motion is taken to be definitional. But FrameNet does not officially make the distinction between circumstance and argument frame. In factoring the two apart, I have left the requirement for a path as part of argument structure, a frame called directed-motion. Thus, it is the pair of ⟨path-specifying-motion, directed-motion⟩ which corresponds to the FrameNet frame. Throughout this paper, FrameNet frames will correspond to such circumstance-argument-structure pairs.

Path: rode west, rode *through the desert*, rode *along* merrily
Goal: skipped *into the park*, walked *over*, *ran up* (goal as implicit arg)
Speed: rode *at a good clip*, hobbled along *at 5 miles a day*
Motion-Manner: tangoed *smoothly*, traveled *on foot*
Distance: hobbled *six feet*, hiked *a short distance*
Area: bounced *all around the room*, scurried *about*, ran *around*, walked *in the middle of the road.*

The verbs have been sorted into 3 classes, those encoding manner, those encoding path shape, those which do neither, and whose status is therefore unclear with respect to that distinction.

We propose the following. Verbs that specify neither path nor manner (like *go*) are directly associated with the self-motion frame; those specifying one or the other are associated with either *path-shape-motion* and *locomotion-manner-motion.*

Related to these circumstance frames but distinct from them there is a set of argument frames. For example, there is *directed-motion*, which provides an argument structure for motion events with oblique paths.[13] We formalize the notion of circumstance and argument frames for these concepts in the next sections.

3.1. Self Motion Circumstance Frame

Here are the role and sort axioms relevant to our *self-motion* frame defined as a specialization of action.

[13] One might also hypothesize a distinct argument frame *directed-action* for the transitive realizations available to many of the path-shape verbs:

i enter the room

ii traverse the ridge

iii exit the room

We leave open for now the question of whether these examples belong to a separate argument frame, which obviously interacts with the exact formulation of a linking theory.

(24) Actor frame :

(a) $\textbf{action} \sqsubseteq \textbf{eventuality}$
(b) action : $\textbf{action} \mapsto \textbf{truth-values}$
(c) *actor* : $\textbf{action} \mapsto \textbf{animate}$

Self-motion frame :

(d) $\textbf{self-motion} \sqsubseteq \textbf{action}$;
(e) self-motion : $\textbf{self-motion} \mapsto \textbf{truth-values}$
(f) *self-mover* : $\textbf{self-motion} \mapsto \textbf{animate}$
(g) *origin* : $\textbf{self-motion} \mapsto \textbf{entity}$
(h) *destination* : $\textbf{self-motion} \mapsto \textbf{entity}$
(i) *path* : $\textbf{self-motion} \mapsto \textbf{path}$
(j) *speed* : $\textbf{self-motion} \mapsto \textbf{speed}$
(k) *distance* : $\textbf{self-motion} \mapsto \textbf{distance}$
(l) *area* : $\textbf{self-motion} \mapsto \textbf{location}$

We can represent the self-motion axioms as an attribute-value structure:

$$\begin{bmatrix} \textit{self-motion} & \\ \text{self-mover} & \textbf{entity} \\ \text{destination} & \textbf{place} \\ \text{origin} & \textbf{entity} \\ \text{path} & \textbf{path} \\ \text{speed} & \textbf{speed} \\ \text{distance} & \textbf{distance} \\ \text{area} & \textbf{place} \end{bmatrix}$$

Note that roles may be inherited. Because roles are defined on sorts, which are simply sets, role inheritance follows from the subsort relation. All *self-motion* instances will be defined not only for the explicitly declared *self-mover* role, but also for the *actor*. role, because **self-motion** is a subsort of **action**. This leaves it open what relation holds between inherited roles like *actor* and roles local to a frame like *self-mover*.

To allow local and inherited roles to be related, we introduce statements of the the following form:

$$\textit{self-mover} :== \textit{actor}$$

We use the symbol :== to express **role congruence**. Role congruence holds whenever the role on the left of :== is constrained to be equal to the role on the right. The congruence of r_1 to r_2, written,

$$r_1 :== r_2$$

holds if and only if, for all eventualities e in the domain of r_1,

$$r_1(e) = r_2(e).$$

Thus, it must be the case that:

$$\mathrm{Dom}(r_1) \subseteq \mathrm{Dom}(r_2).$$

The axioms in (24) describe the participants of self motion verbs, whether they encode manner of motion or path shape. We now try to capture the fact that encoding manner of motion is a pattern for a class of English verbs. We shall do this by defining an specialization of the self-motion frame which requires manner of motion to be lexically specified:

manner-specifying-self-motion $\sqsubseteq$ **self-motion**
locomotion-manner :
    manner-specifying-self-motion $\mapsto$
        locomotion-method
locomotion-method = { walking-motion, sauntering-motion,
    trudging-motion, sashaying-motion,
    skipping-motion, slithering-motion, . . .}
incorporated(*locomotion-manner*)

Here we have simply said that the *manner-specifying-self-motion* frame is a specialization of *self-motion* in which a new frame element has been defined. The new frame element is the *locomotion-manner* attribute; it is appropriately filled by anything of sort **locomotion-method**, and a partial list of those entities has been suggested. The last line of the definition applies a higher-order predicate incorporated to the *locomotion-manner* attribute. The important feature of the incorporated predicate is this:

Incorporated attributes must be filled in a lexical axiom. Thus, declaring an incorporated role defines a class of verbs that lexically specify it.

For path-shape verbs we have the following:

path-specifying-self-motion $\sqsubseteq$ **self-motion**
path-shape : **path-specifying-self-motion** $\mapsto$ **path-shape**
path-shape = { squiggly, ascending, descending,
into-goal, from-goal, out-of-goal, ...}
incorporated(*path-shape*)

In sum we have followed others, including Talmy (1985) and formalized the claim that English has two distinct ways of classifying circumstances with agentive motion, path-specifying and manner-specifying. In the next section, we present the mapping of those circumstances into argument motion.

3.2. The Argument Frame for Self-motion verbs: Directed-Motion

We propose the following as the argument frame for all the self-motion verbs:

(25) **directed-motion** $\sqsubseteq$ **motion**
directed-motion : **directed-motion** $\mapsto$ **truth-values**
location : **directed-motion** $\mapsto$ **location**
resultant-location : **directed-motion** $\mapsto$ **location**
theme : **directed-motion** $\mapsto$ **entity**
goal : **directed-motion** $\mapsto$ **entity**
path : **directed-motion** $\mapsto$ **path**

Note that the *resultant-location* role calls for something of sort **location**. We propose that location relations, too, be captured by a frame:

location $\sqsubseteq$ **sort**
location : **location** $\mapsto$ **truth-values**
figure : **location** $\mapsto$ **entity**
ground : **location** $\mapsto$ **place**

The location frame simply describes a relation between a figure and ground. There will be various specializations whose particular features involve both spatial configurations such as axis orientation and surface contact, and non-spatial notions such as support (Herskovits, 1986).

The intent is that the ground in the the *resultant-location* eventuality of a *directed-motion* be the same as its *goal*, This constraint can be stated directly using function composition:

$$\mathit{goal} = \mathit{ground} \circ \mathit{resultant\text{-}location}$$

That is, composing the *ground* and *resultant-location* relations gives us the same relation (extensionally) as the *goal* relation. A parallel constraint relates the *theme* role and the *figure* of the *resultant-location*:

$$\mathit{theme} = \mathit{figure} \circ \mathit{resultant\text{-}location}$$

Summing up the axioms for *directed-motion* and *location* in attribute-value notation, we have:

(26)
$$\begin{bmatrix} \mathit{directed\text{-}motion} & \\ \text{goal} & \boxed{1} \\ \text{theme} & \boxed{2} \\ \text{resultant-location} & \begin{bmatrix} \mathit{location} & \\ \text{figure} & \boxed{2} \\ \text{ground} & \boxed{1} \end{bmatrix} \\ \text{path} & \textbf{path} \end{bmatrix}$$

Before trying to define the exact relationship between the *self-motion* frame and the *directed-motion* frame, we note the following differences:

1. *Directed-motion* has no roles corresponding to *speed* and *distance*. These will be analyzed as measure properties of the path complex.

2. *Directed-motion* has no roles corresponding to *source* and *area*. Both of these are regarded as part of the path complex, another eventuality role with its own frame. We leave discussion of the complex subject of paths to future work.

3. The *self-motion* frame has no eventuality roles. The *directed-motion* frame has two, *path* and *resultant-location*.

The general function of an eventuality role in this paper is to identify a participant that is expressed by a secondary predication, that is, to consider a set of possibilities, by:

1. An adposition phrase (example: English spatial goals)

2. An affix on the main predicational element that changes its argument structure (example: English *out-*, as in *out*shoot someone, Slavic prefixes)

3. The non head verb in a verb verb compound(example: Japanese verb verb compounds)

4. a particle or adverbial (English verb particles)

5. a non-finite clausal complement (example: Japanese *toote*, a gerundive form of *toru*, *pass*, used to introduce path expressions meaning *through*)

6. a relational or event nominal (example: levy a *fine*)

Eventuality roles, then, belong conceptually to the realm of argument structure, because they capture a "decision" to encode certain information about a role-filler in a complex predication. When we speak of a decision, we mean simply a realization of some semantic material that might have been otherwise, the key evidence being that we observe cross-linguistic or intra-linguistic variation.

For example, in English, we see goals realized both as direct objects and as obliques:

(27) a. We went into the house.
b. We entered the house.

Recognizing the key role of secondary predications in argument structure introduces a host of problems. Most importantly, the same syntactic devices that sometimes serve to factor a single set of circumstances into two predications may also serve other functions, so that it is an analytical challenge to to determine when they are true secondary predications:

1. Adpositional complements may be simple role markers (the *of* phrase with *hypotenuse* or external adverbials that introduce frames of their own

2. An affix that changes argument structure may not carry much much semantic information. Slavic and Hungarian prefixes generally seem to; the English passive morpheme does not (other than the valence changing information it encodes).

3. Particles, non-finite clausal modifiers, and adverbials may be external frame-introducing modifiers.

4. Relational and event nominals may occur with predicates that do not match their circumstances:

   levy a fine
   resent a fine

Nevertheless the concept that sometimes a single lexical concept may be broken up into separate predications seems quite well-established. We review some simple motivations in the next section.

Having now briefly argued for separate circumstance and argument frames for self-motion verbs, we now present some axioms that relate them:

self-motion- directed-motion :
self-motion $\mapsto$ **directed-motion**
(a) $\mathit{destination} = \mathit{goal} \circ$ self-motion-directed-motion
(b) $\mathit{area} = \mathit{ground} \circ \mathit{location} \circ$ self-motion-directed-motion
(c) $\mathit{self\text{-}mover} = \mathit{theme} \circ$ self-motion-directed-motion

Axiom (a) projects the destination role, typed to be a place in the self-motion frame, to the *goal* role. Axiom (b) projects the area role, also typed to be a place, into the *ground* role of the *location* of the directed motion. Finally axiom (c) projects the self mover as the theme of the motion.

The semantics of the directed motion argument frame is just motion along a path, either agentive or non agentive. We assume that verbs like *trickle* and *fall* will both use directed-motion, along with the self-motion verbs.

This leaves, finally, the task of writing an axiom to define a particular verb. Axiom (28) is an example of such an axiom, defining the verb *hop*:[14]

(28) a. $\text{hop}(e) \longleftrightarrow \exists e'[\ \text{self-motion-directed-motion}(e', e) \wedge$
$\qquad\qquad\qquad\qquad \textit{locomotion-manner}(e') = x \wedge$
$\qquad\qquad\qquad\qquad \text{hoppity}(x)]$

b. $\text{hop} = \text{hoppity} \circ \text{locomotion-manner} \circ \text{self-motion-directed-motion}^{-1}$

(28a) and (28b) defining *hop*. A hopping eventuality must stand in the self-motion-directed-motion relation to some event e' and, therefore, by the definition of that relation, e must be a directed motion and e' a self-motion. Moreover, the locomotion manner of e' must be hoppity. Axiom (b) merely states this in terms of the composition of several relations, beginning with the inverse of self-motion-directed-motion. That inverse is a mapping from directed motions to self motions. Thus *hop* is defined as a predicate true of directed motions that are related to a self motion whose locomotion manner is hoppity.

We call either version of (28) a **lexical axiom**. We require every word sense to have a defining lexical axiom. All entailment properties of the lexical item thus need to be stated in terms of the frames and specializations licensed by the lexical axiom. In the case, of *hop*, that means all entailment properties either need to follow from being a manner specified self-motion frame or from the hoppity motion manner. Similarly all semantic compatibility facts must follow from the role constraints of the self-motion frame.

3.3. Motivating eventuality roles

In this section we motivate the idea of eventuality roles that capture secondary predications within frames, since this is the key feature distinguishing self motion from directed motion. We will begin with the *resultant-location* role used to encode secondary predications about goals.[15]

[14] We adopt the convention, familiar from Prolog, that variables on both sides of the axiom may be viewed as universally quantified. We introduce existentials explicitly where necessary.

[15] The idea being motivated here is not new. Some sort of complex predicational treatment of goal is common to most lexical semantic representations. As a number of researchers have noticed,[16] the semantic nature of goals must

A key indicator that goals involve a secondary predication is that they can be marked by so many different prepositions, even with one verb. Consider modifiers like *in the closet*, *on the plate*, *inside the apple*, and *60 miles from Boston* in the following example:

(29) John threw the button $\left\{\begin{array}{l}\text{in the closet.}\\ \text{on the plate.}\\ \text{inside the apple.}\\ \text{60 miles from Boston.}\end{array}\right.$

All of these indicate the final location of the button's motion path, even when pragmatically unlikely. Clearly there is something more specific than mere goalhood being predicated, since all these phrases also encode distinct spatial relations. English has a rich inventory of ways of marking spatial relations.

Moreover, all the phrases in (29) can be simple locative modifiers as well:

(30) The button was $\left\{\begin{array}{l}\text{in the closet.}\\ \text{on the plate.}\\ \text{inside the apple.}\\ \text{60 miles from Boston.}\end{array}\right.$

Cross-linguistically, some overlap in the marking of the locative and goal relations is well-attested. For example, Japanese uses *ni* for both; in Slavic, there is a class of prepositions that mark both goal and location, with an alternation between accusative and locative case government signaling the difference.

The following two conclusions can be reached for English: (a) English marks a large inventory of spatial relations between figures and grounds, and thus provides a variety of ways to specify a location. Following the methodology of providing circumstance frames for each semantic paradigm, this suggests a circumstance frame is needed for the location relation. (b) Independently of the spatial relation used to specify a location, there is the question of what role the location is playing with respect to the main clause: Is it static location, source, or path endpoint? The same locative prepositions can mark all three kinds of locations:

be complex. Our goal in this section is to explore the consequences of this idea for argument structure.

(31) a. The boat is under the bridge
b. The boat went under the bridge.
c. The boat floated out from under the bridge.

These facts suggest that source and goal locations, at least, involve complex predications with two components, the spatial relation identifying a location, and the role of the location with respect to a motion event. This is what the argument frame structure in (26) attempts to capture. In contrast the circumstance frame *self-motion* is just a flat list of participants, with no attempt to factor the information into distinct predications. That factoring is a product of how a language chooses to encode information about a particular set of circumstances. It thus belongs to argument structure.

Another reason for believing in something like the decomposition of locative meaning into eventuality roles like *resultant-location* and spatial relation is that in some languages it is spelled out a bit more explicitly. Japanese location nouns are a case in point.

(32) a. He put the book inside the box.
kare wa hon o [box]-no-naka-ni [leave]
b. He-nom book-adnom inside loc put-past.

Here the *ni* marking may be thought of as corresponding to the *location* role and the locational noun *inside* to the exact spatial relation.

We assume all spatial goals involve some version of the *resultant-location* role. For example, simplifying somewhat, the spatial goal of a *throwing* eventuality can be represented as follows:

$$\begin{array}{l}\mathrm{throw}(e) \wedge \mathit{thrower}(e) = \mathrm{john} \wedge \mathit{thrown}(e) = \mathrm{button} \wedge \\ \mathit{goal}(e) = \mathrm{box} \wedge \mathit{resultant\text{-}location}(e) = l \wedge \\ \mathrm{in}(l) \wedge \mathit{ground}(l) = \mathrm{box}\end{array}$$

In contrast, true locatives will involve a distinct eventuality role. For *John ate an apple in the restaurant*, we have, schematically:

$$\begin{array}{l}\mathrm{eat}(e) \wedge \mathit{eater}(e) = \mathrm{john} \wedge \mathit{eaten}(e) = \mathrm{apple} \wedge \\ \mathit{location}(e) \geq l \wedge \mathrm{in}(l) \wedge \mathit{ground}(l) = \mathrm{restaurant}\end{array}$$

There are three important differences. First, the *location* role is not lexically functional. This reflects that facts that location modifiers can iterate; thus we allow any appropriate eventuality to have multiple related location eventualities. Second, the filler of the embedded *ground* is not identified with any argument role of the matrix e, in contrast to the figures of resultant locations, which are identified with the *goal* role. Third, what is located is not one of the participants of the eating eventuality, but the eventuality itself. This is one way in which the concept of an external adjunct can be reconstructed within the neo-Davidsonian framework: external modifiers of a head eventuality e fill eventuality roles within which e itself figures as a role filler. To capture this in frames we need the concept of a *self* role filled by the frame eventuality, defined for all frames:

$$\textit{self}(= \mathrm{I}_{\textbf{eventuality}}) : \textbf{eventuality} \mapsto \textbf{eventuality}$$

Schematically, we would have:

$$\begin{bmatrix} \textit{action} & \\ \text{rel} & \text{eating} \\ \text{self} & \boxed{1} \\ \text{actor} & \boxed{2} \\ \text{patient} & \boxed{3} \\ \text{location} & \begin{bmatrix} \textit{location} & \\ \text{figure} & \boxed{1} \\ \text{ground} & \boxed{4} \end{bmatrix} \end{bmatrix}$$

Summing up the discussion to this point: We have motivated a “structural element” of argument structures, the factoring of information into separate predications, using the example of spatial relations. The technical consequence of this is that argument frames include eventuality roles which may be filled by secondary predicators evoking frames of their own and specifying independent relations. Our assumption throughout this paper is that this feature is not limited to the spatial domain.

Consider the case of modifiers marked with *for* and *against* in a variety of circumstances involving communication:

(33) a. He campaigned for nuclear disarmament.
b. He campaigned against nuclear proliferation.
c. # He campaigned for disarmament against proliferation.
d. He spoke against disarmament.
e. # He spoke about proliferation against disarmament.
f. He spoke about proliferation.

This data suggests the following picture: communication verbs like *campaign* and *speak* have a single circumstantial participant connected with the content of what is being said. Thus (33c) and (33f) are infelicitous because they involve simultaneous distinct ways of filling a functional role. Content relations include *supported* (marked by *for*), *opposed* (marked by *against*), and *topic* (marked by *about*).

To account for this array of facts, let us suppose that a very general frame called **communication** has an eventuality role called **content**:

$$\begin{bmatrix} \textit{communication-frame} & \\ \text{communication} & \textbf{communication} \\ \text{communicator} & \textbf{animate} \\ \text{content} & \begin{bmatrix} \textit{content} & \\ \text{topic} & \textbf{entity} \end{bmatrix} \end{bmatrix}$$

$$\mathbf{opposition} \sqsubseteq \mathbf{content}$$
$$\textit{opposed} :== \textit{topic}$$
$$\mathbf{support} \sqsubseteq \mathbf{content}$$
$$\textit{supported} :== \textit{topic}$$
$$\mathbf{aboutness} \sqsubseteq \mathbf{content}$$

There is a communication frame intended to be the argument frame for verbs like *speak*, in which there is a communicator and a content.[17] Content is an eventuality role specialized in three ways, to opposition, to support, and to aboutness.[18]

[17] A verb like *campaign* will also be related to this argument frame, but by having a speaking subscene abstracted out of it, analogous to the the way possession transference subscenes are abstracted out of commercial events in Section **??**.

[18] We leave out the details of the circumstances of communication, but we note in passing that *communication*, like *donation* and acquisition in

The facts in (33) are then accounted for by associating one sense of *about* with *aboutness*, one sense of *for* with *support*, and one sense of *against* with *opposition*:

$$\begin{aligned}
[\![\text{for}]\!] &= \lambda x, e[\text{support}(e) \wedge \mathit{supported}(e) = x\,] \\
[\![\text{against}]\!] &= \lambda x, e[\text{opposition}(e) \wedge \mathit{opposed}(e) = x\,] \\
[\![\text{about}]\!] &= \lambda x, e[\text{aboutness}(e) \wedge \mathit{topic}(e) = x\,]
\end{aligned}$$

The prepositions *for*, *against*, and *about* directly mark roles in a content eventuality.[19]

Thus, one important consequence of positing eventuality roles is that they provide a natural way of describing paradigmatic relations among modifiers like the above contentative phrases.

Allowing argument structures to encode complex predications raises the question of how to draw the line between bi-clausal and mono-clausal constructions. The issue is not a simple one. Languages vary considerably in how much material they can pack into a single clause by complex predication, as famously noted for motion constructions(Talmy, 1985). Sometimes that variation shows up in surprising places, leading us to consider embedded eventuality analyses where we might not have before. Consider the verb *ransack* as in

(34) John ransacked the room for drugs.

The verb *ransack* patterns with a number of English verbs, called verbs of searching and investigating in Levin (1993) and verbs of

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the previous section, is an argument frame defined relative a particular set of circumstances. Independent evidence for the need for such an argument frame comes from verbs like *cry* and *groan*, which are not primarily verbs of communication, but which can be coerced into communication uses (*He groaned about his workload*). We assume there is a sense transfer involved, of the sort discussed in Section 6. We assume that the antonmymy relation between *for* and *against*, which shows they are in a closer relation to each other than to *about*, should be accounted for at the level of circumstances.

[19] An interesting consequence of this proposal on the circumstance side, is that the participant projection of certain participants may involve reference to more than one argument structure eventuality. Thus, suppose that *speaking* circumstances have favored-issue and opposed-issue participants. Then the projection axioms look like this:

$$\begin{aligned}
\mathit{favored\text{-}issue} &= \mathit{supported} \circ \mathit{content} \circ \text{speaking-communication} \\
\mathit{opposed\text{-}issue} &= \mathit{opposed} \circ \mathit{content} \circ \text{speaking-communication}
\end{aligned}$$

.

scrutiny in FrameNet, that fit in the template:

Verb NP_{loc} for NP

These include *examine* and *search*. They all describe searching a location for something.

In Japanese, (34) cannot be expressed in a single clause. Instead, an embedded non-finite clause must be added to include the sought object

(35) Japanese ransack *ateru*

What is striking about this case is that the sought object is still entailed by *ateru*. That is, as with English *ransack*, one cannot perform the action *ateru* without having some object one is searching for. One possibility is to analyze this along the lines we followed in analyzing *cost*. We may simply say that *ateru* is a simple predicate and that the sought for participant is unprojected. Then connecting the participant in the embedded clause with the implied thing being sought for is a matter of pragmatics.

Another possibility is to concede that what may be simple predicates in one language may be complex in another and adopt a embedded eventuality analysis of *ateru*. That is, a role is provided for the thing being sought for, but it needs to be mediated by a second relation. The action of ransacking is complex; it involves two relations, first a searching activity that takes place in and affects a location, and second, a relation between the searcher and the goal that directs this activity, the relation of trying to find a certain object. That second relation can be expressed without the first in predicates that are logically simpler, such as *seek*.

For whatever reason, perhaps because it has no argument frame appropriate for the task, Japanese does not lexicalize the ransacking relation as a simple predicate. But we may still regard the gerundive clauses that attach to *ateru* as argument fillers that introduce a secondary predication. That secondary predication, like a locative, fills an eventuality role typed for a seeking eventuality.

This now lead us to the question of how different English and Japanese are in this case. Let us assume that the two languages have described the same circumstances, called *scrutiny* as in FrameNet, with *ateru* and *ransacking*, projecting three frame elements into argument structure. *seeker*, *phenomenon*, and *seeking-location*. One way of describing the difference between English and Japanese is to say that Japanese projects the *phenomenon* into an eventuality role and English does not. For concreteness, call that proposed English argument role the *desired-object* role:

$$\begin{bmatrix} \textit{english-scruting} & \\ \text{seeker} & \boxed{1} \\ \text{seeking-location} & \boxed{2} \\ \text{desired-object} & \boxed{3} \end{bmatrix}$$

In contrast, Japanese maps *phenomenon* to an eventuality role, call it *purpose-sit*, which in turns has a role for what is sought for, call it *sought-for*:

$$\begin{bmatrix} \textit{japanese-scrutiny} & \\ \text{seeker} & \boxed{1} \\ \text{seeking-location} & \boxed{2} \\ \text{purpose-sit} & \begin{bmatrix} \textit{seeking} & \\ \text{seeker} & \boxed{1} \\ \text{sought-for} & \boxed{3} \end{bmatrix} \end{bmatrix}$$

The *sought-for* role is then appropriate for a secondary predicational filler with a *seeking* eventuality type, such as the above gerundive clause.

Alternatively we might say that Japanese and English have the same argument structures, both taking the alternative marked Japanese, and that the English preposition *for*, like spatial goals and contentatives, marks an eventuality role. This means we could treat the following English example in a manner parallel to the Japanese sentence in (35):

(36) John ransacked the room looking for drugs.

The difference between Japanese and English, then, would largely be that English has a special syntactic category for secondary predicators, prepositions, and one of these in particular, *for*, is appropriate to expressing seekings. In Section 7, we will pursue, for a large class of *for*-phrases, a variant of the alternative marked Japanese here. Here we simply note the attractiveness of such an account on general grounds of economy.

4. Circumstance Frames and Argument Frames

4.1. Commercial events and commercial event predicates

Let us return to the example of the commercial event predicates discussed in Section 1. As noted there, commercial event predicates differ dramatically in their valence patterns. Following the work in FrameNet, we can describe these differences as follows:

Commercial event

(37)

buy: an acquisition with goods profiled

sell: a giving with goods profiled

pay: a giving with money profiled

spend: resource consumption with resource (money) profiled

cost: resource consumption with resource-owner (buyer) profiled.

For present purposes, we'll define "profiled" as "realized as logical direct object".[20] Descriptively, what we are capturing when we say a selling is a giving is that the valence of *sell* patterns with verbs like *give*. Similar observations apply to other cases. Here are some examples of *Commercial Event* verbs together with other verbs whose valences they pattern with:[21] We shall also have something to say about commercial event nouns like *cost*.

[20] We will make this definition precise in Section 5.

[21] The primary difference between the work described there and the framework here is that Fillmore does not attempt to capture the image of the relation — the argument frame — by means of a frame.

4.2. Commercial Event Verbs

Commercial event

1. buy: get, acquire, take
2. sell: give, send, bequeath
3. pay: give, send, bequeath
4. spend: use up, burn up, waste, throw away, lose, gamble, risk
5. cost: take, lose [with the NP NP[Meas] valence]

N cost

The general descriptive property motivating the division between circumstance and argument frames is that the valence capturing classification cross-cuts the circumstantial classification. There are verbs describing other sorts of circumstances with the same valence pattern, and there are verbs describing the same circumstances with other valence patterns.

In Section 2.1, we introduced the *giving* and *acquisition* frames as the argument frames for verbs like *give* and *acquire*, verbs that describe basic acts of possession transfer. In this section we show how verbs with more complex sets of circumstances which still entail possession transfer can exploit the same argument structures.

In the discussion that follows, we assume two circumstance frames, money transaction and commercial event: with the latter a specialization of the former:

$$\begin{array}{l}\textbf{money-transaction} \sqsubseteq \textbf{eventuality} \\ \textbf{commercial-event} \sqsubseteq \textbf{money-transaction}\end{array}$$

$$\begin{bmatrix} \textit{money-transaction} & \\ \text{payer} & \boxed{1} \\ \text{payee} & \boxed{2} \\ \text{money} & \boxed{3} \end{bmatrix}$$

$$\begin{bmatrix} \textit{commercial-event} & \\ \text{buyer} & \boxed{1} \\ \text{seller} & \boxed{2} \\ \text{money} & \boxed{3} \\ \text{goods} & \boxed{4} \end{bmatrix}$$

We have used co-indexing to represent the role equations involved in the inheritance. The *payer* is specialized to be *buyer* in commercial events; the *payee* role is specialized top be *seller*. The *money* role is directly defined by inheritance, and the *goods* role is novel to commercial events.

The intention is that money transaction include any money transfer involving a socially or legally sanctioned obligation, thus including fine and tax payments, rent payments, loan payoffs, but excluding the surrender of money to a mugger.

The following axioms describe a *subscene projection* of the commercial event frame. Subscene projections will provide a vehicle allowing more complex frames to be related to simple argument frames. They will also play a key role in our account of participant omission.

(38) a. $\textit{goods-transfer}_{\sqsubseteq}$: $\textbf{commercial-event} \longleftrightarrow \textbf{possession-transfer}$

b. $\textit{buyer} = \textit{recipient} \circ \textit{goods-transfer}$
$\textit{seller} = \textit{donor} \circ \textit{goods-transfer}$
$\textit{goods} = \textit{theme} \circ \textit{goods-transfer}$

Formula (38a) is a role declaration defining an eventuality role for a *possession-transfer* abstracted out of a *commercial event*. Note that the *goods-transfer* role is a total one-to-one function. Thus, it is defined so as to give an existential entailment: every commercial event has associated with it a unique goods transfer eventuality. The axioms in (38b) define the role-alignments between a commercial event and its associated goods transfer by requiring functional equality of 3 projected commercial event participant roles and three composite roles. Paraphrasing those compositions in English, we have

1. The recipient of the goods transfer is the buyer;

2. the donor of the goods transfer is the seller;

3. the theme of the goods transfer is the goods.

We call *goods-transfer* a *subscene role*, because it abstracts a subevent out of as commercial event. We will adopt the convention of subscripting such roles with the SUB-EVENT designation $\sqsubseteq$. We call the axioms in (38b) **subscene projection axioms**.

We can also represent this subscene projection AVM-style:

(39)
$$\begin{bmatrix} \textit{commercial} & \\ \text{rel} & [\,] \\ \text{buyer} & \boxed{1} \\ \text{seller} & \boxed{2} \\ \text{money} & \boxed{3} \\ \text{goods} & \boxed{4} \end{bmatrix} \overset{\text{goods-transfer}_{\sqsubseteq}}{\mapsto} \begin{bmatrix} \textit{possession-transfer} & \\ \text{rel} & [\,] \\ \text{recipient} & \boxed{1} \\ \text{donor} & \boxed{2} \\ \text{theme} & \boxed{4} \end{bmatrix}$$

The chief benefit of having defined a subscene projection from commercial events to possession transfers is that we already defined argument projections for possession transfers. Thus by composing a commercial event subscene projection with a possession transfer argument projection we have an argument projection for commercial events.

For example, in Section 2.1 we introduced the abstraction relation *acquisition*, which maps a possession transfer into an acquisition, in which the recipient is viewed as an actor. With this projection, we now have the ingredients to write a lexical axiom for *buy*:

(40) $\text{buy} = \text{commercial-event} \circ (\text{acquisition} \circ \text{goods-transfer})^{-1}$

We may view (40) as definitional for this sense of *buy*. What I mean by definitional is that no other axioms need mention the predicate *buy*.[22] Saying that a buying is the goods acquisition of a commercial event says all we need to say. Everything else can be explained in terms of what we know about commercial events and acquisitions. It is in this sense that the account may be viewed as reductive and decompositional. We are decomposing a buying event into two semantic components, acquisition and commercial event.

Axiom (40) puts buying eventualities into a mutually entailing relationship with commercial events. Note that it also entails that each buying event is an acquisition event. In Section 5, we show how the valence properties of *buy* follow from denoting *acquisition* eventualities.

Note that no mention is made of the money in (38), although the money may certainly be realized with *buy*:

(41) John bought the Miata for 20K.

This decision will eventually lead to an analysis which draws the conventional line between arguments and adjuncts so as to include the goods and exclude the money with verbs like *buy*. This decision will be defended in Section 7. In effect, we are saying that the occurrence of the money *for*-phrase is not something licensed in virtue of viewing the commercial event as an acquisition.

The account for *sell* is symmetric, but relates the goods transfer to a goods giving instead of a goods acquisition. The required lexical axiom follows: Axiom (42) defines a *sell* in terms of a goods-transfer.

(42) $\text{sell} = \text{commercial-event} \circ (\text{giving} \circ \text{goods-transfer})^{-1}$

We assume that what distinguishes buyings from sellings is what distinguishes givings from acquisitions; a selling is a possession transference events in which the giver is an actor. In virtue of being a giving, a selling eventuality is eligible for the same the

[22] The exception will be sense transfer axioms, which will state the relationship of a new sense to *buy*; they mention *buy*, but their function is to define new predicates in terms of it, not to define or further constrain *buy*.

valence pattern as that used by the verb *give*, in which the *giver* is subject and the the *recipient* is marked with *to*.

It is worth noting that this account captures the entailment relations between *buy* and *sell*. The subscene projection relation *goods-transfer* is a one-to-one function from commercial events to possession transfers; composing that with acquisition, we get a function

$$\text{goods-transfer} \circ \text{acquisition}$$

from acquisitions (**act-th-go**s associated with a possession transfer) to commercial events; so the inverse is a function from acquisitions to commercial events, restricted to acquisitions that transfer the goods of a commercial event. The same possession transfer associated with an **act-th-go** must also be associated with a **act-th-so**, because the giving mapping is total. Thus there is a giving event assoicated iwth the same goods transfer, and the account of the mutual entailment of *give* and *receive* extends to provide an account of the mutual entailment between *buy* and *sell*.

Next we turn to *pay*, which is like *give* except with the money given instead of the goods, and unlike *give* in that it requires no goods. Verbs like *buy* and *sell* specifically require a commercial event involving a transaction with goods. There are other kinds of commercial transactions, however, which involve money transfer to cover an obligation, but which have no goods. Thus we have fines, rents, taxes, loans. The distinguishing feature of the verb *pay* is that that it can be used to describe all of these kinds of money transactions as well as those with goods, while the verbs *buy* and *sell* cannot. And even when we introduce the goods overtly with *pay*, there are subtle differences in the truth the conditions:

(43) John $\left\{\begin{array}{lll}\text{(a)} & & \text{paid \$200,000 for the house,} \\ \text{(b)} & \# & \text{bought the house for \$200,000,}\end{array}\right.$ but ownership was never transferred because of a title problem.

Example (43a) is much more natural than (43b) because to buy a house without a transfer of ownership is a contradiction; *pay* in contrast, as used in (43a), entails only a transfer of money intended to be in exchange for the house. This contrast is evidence that the circumstances *pay* is connected with are less restrictive than those of *buy*.

We thus define *pay* in terms of the more general *money transaction* frame

(44)

a. $\textit{money-transfer}_{\sqsubseteq}$: **money-transaction** $\mapsto$ **money-transfer**

b. $\textit{buyer} = \textit{recipient} \circ \textit{money-transfer}$
$\textit{seller} = \textit{donor} \circ \textit{money-transfer}$
$\textit{money} = \textit{theme} \circ \textit{money-transfer}$

In AVM style, these projection equations give us:[23]

$$(45)\quad \begin{bmatrix} \textit{money-transfer} & \\ \text{payer} & \boxed{1} \\ & \\ \text{payee} & \boxed{2} \\ & \\ \text{money} & \boxed{3} \\ & \end{bmatrix} \; \overset{\text{money-transfer}_{\sqsubseteq}}{\mapsto} \; \begin{bmatrix} \textit{possession-transfer} & \\ \text{rel} & [\,] \\ \text{recipient} & \boxed{2} \\ & \\ \text{donor} & \boxed{1} \\ & \\ \text{theme} & \boxed{3} \end{bmatrix}$$

(46) $\text{pay} = \text{money-transaction} \circ (\text{money-transfer} \circ \textit{giving})^{-1}$

Before turning to the axioms for *spend*, we need to note several properties that distinguish it from the verbs discussed thus far.
Consider:

(47) I spent 300 dollars on my car.

Given the economics of car-buying, what this sentence is most likely to describe is the cost of an auto repair. It is still a commercial event, but the car is not the goods; the parts and labor of the unexpressed repair job are. On the other hand:

(48) I spent 300 dollars for my car.

seems to preclude the repair shop scenario. Thus *spend* allows a new participant when used with *on, but that participant is not*

[23] In Section 7, we show how to deduce some of these role axioms for money transfer from general properties of exchanges and the facts that commercial events are changes.

expressible when for *is used. We will call the argument marked with* on *a non-participant argument* because it is not a participant in the circumstances.

The situation is further complicated by the fact that sometimes the *on*-phrase does express the goods:

(49) I spent 300 dollars on that sweater.

In this case some kind of default reasoning seems to be in play.

The other problem was previewed in Section 1: Sometimes participant projection loses participants. Consider the fact that the *seller* can't be realized with *spend* and *cost*.

The following axioms deal with *spend*.

(50)

a. $$\begin{bmatrix} \textit{commercial-event} & \\ \text{money} & \boxed{1} \\ \text{buyer} & \boxed{2} \\ \text{goods} & \boxed{3} \\ \text{seller} & \boxed{4} \end{bmatrix} \xrightarrow[\text{money-consumption}_{\sqsubseteq}]{} \left\{ \begin{bmatrix} \textit{resource-consumption} & \\ \text{resource} & \boxed{1} \\ \text{consumer} & \boxed{2} \end{bmatrix} \right\}$$

$$\textit{goods} :== \textit{resource-requirer} \circ \textit{money-consumption}$$

b. $$\text{resource-consumption-ag-th-go} : \textbf{resource-consumption} \mapsto \textbf{ag-th-go}$$

$$\textit{consumer} = \textit{actor} \circ \textit{resource-consumption-ag-th-go}$$
$$\textit{resource} = \textit{theme} \circ \textit{resource-consumption-ag-th-go}$$

In (50a) we define a new circumstance frame *resource-consumption* and a subscene relation that abstracts a resource consumption out of a commercial event. In (50b) we give the participant projection axioms for realizing resource consumptions using the abstraction relation *resource-consumption-ag-th-go*.

There are several unusual features of this projection. First the relation that abstracts out a subscene is total but not not one-to-one. Thus there will be at least one and possibly many money-consumption eventualities for each commercial event. The next point of note is that *resource-consumption* in (50a) is a frame with three roles, but in the projection axioms in (50b), only two commercial event participants are identified with *resource-consumption* roles. The omission of the *seller* as an argument with *spend* is now explained by the simple fact that the *seller* has been left out of the subscene that a commercial event projects.

We assume the following principle for participant omission:

Participant Omission Principle

> A participant may be omitted from the participant projection of a circumstance-frame only if there is a subscene relation projecting that circumstance frame into a subscene which omits that participant.

Two points may be noted in applying the principle. We would like that subscene circumstance to be independently motivated. Thus it is important that frames like possession transfer and resource consumption are motivated by verbs outside the domain of commercial events. Second, in applying the principle we must attend to the difference between participant and attribute introduced with the *path-shape-self-motion* frame. Attributes like path-shape do not have to be projected.

The lexical axiom for *spend* follows:

(51) $$\text{spend}_{\text{ce}} = \text{commercial-event} \circ (\text{money-consumption}^{-1} \circ \text{resource-consumption-ag-th-go})^{-1}$$

The money consumption projection illustrates an important point about subscene projection and circumstances. Both argument frames and circumstances have subscenes. The difference is that with argument frames those subscenes are **structural**. There is one and only one way of carving an argument frame into subscenes, because the job of an argument frame is to represent a canonical way for the language to encode a sense, which entails a particular way of marking complex scene structure. Thus, for a number of cases of valence alternation, as discussed in Section 6, a sense transfer rule is needed. A given circumstance, though, may be carved up into subscenes in a number of different incompatible ways. Thus the resource consumption eventuality crosscuts the goods and money transfers. The goods and money transfers taken together can be seen as framing a commercial-event as an exchange.[24] But the view of a commercial event as a consumption of the buyer's resources is incompatible with that view. It is just a different way of looking at the commercial event, which abstracts out a different subscene. The verb *charge*, which we do not discuss here for reasons of space, takes still a different incompatible view, in which the buyer, seller, and money are selected, but not put into a configuration typical of possession transfer:

(52)	John charged	Mary	$300.
	recipient	donor	theme

Claiming that *charge* describes a possession transfer of the money does not explain why the *donor* of the money should appear in indirect object possession. If we want to treat (52) as a possession transfer it must be a transfer that arises out of a rather unusual view of a commercial event, in which what is transfered from John to Mary is a bill or an obligation. The point in raising such difficult cases is simply to underline that the relation between between circumstances and subscenes is more indeterminate, a choice of perspective which may introduce new participants.

This brings us to the subject of the third role in a resource consumption. Note that the projection of the goods in (50a) is not represented avm-style, but is accounted for in a separate axiom. The goods role is **congruent** but not identical with the *resource requirer* role. What this means is that every commercial event must have *some* associated resource-consumption event in which the goods is the resource-requirer, but there may also be some associated resource consumption in which it is not. This covers the case of the car repair. The commercial event is one in which the goods is the parts and services. There is an associated resource consumption in which the parts and service are described as resource-consumer:

(53) I spent $300 on my brake job.

There is also an associated resource consumption, for *that very commercial event*, in which the car is the resource, which may be described by (47).

[24] The nature of commercial events as exchanges is discussed in Section 7.

It appears to be the role congruence of the *on* participant that allows it to be interpreted, as a default, as the goods, as in (49). The kind of default reasoning in play is basically abductive(Hobbs et al., 1993). Abduction is inferencing to the best explanation, as in medical diagnosis. If disease p entails symptoms q_1, q_2, and q_3, then the presence of q_1, q_2, and q_3 can be explained by assuming disease p. The conclusion is not logically warranted but it is a useful hypothesis. Similarly, the *money-consumption* axioms say that the goods in a commercial event is always the resource requirer in *some* resource consumption. Therefore, if a hearer assumes that the *on*-phrase marks the goods, she has explained its appearance with *spend*. This is not a logically warranted assumption, but it is a decent working hypothesis if the sentence can naturally be understood that way.

Non-participant arguments are interesting because on many views of argument structure, the appearance of arguments not in the underlying semantics is incoherent,[25] but on a picture that separates argument frames from circumstances, they are not that surprising. Circumstance and argument frames are basically independent. There is a set of argument frames offered by the language and there is a principle (the Entailment Principle discussed in Section 6) constraining the set of argument frames appropriate to any given circumstances, but beyond this, there is some necessary openness in the relation. Circumstances constrain but do not determine what is encoded in the argument frame. This is precisely why *buy*, *sell* and *spend* are different. What non participant arguments show directly is being a circumstantial participant is not a necessary condition for argumenthood. More generally they show that argument frames may not only choose different ways of looking at a single circumstance; they may also add information to it.

Much more could be said about commercial events, but enough has been said here to serve our main purpose, motivating the distinction between circumstances and argument structure. The key idea is that valence pattern classes cross-cut circumstantial classes. One valence pattern may be associated with numerous circumstances and one circumstance with numerous valences.

[25] An example would be the model in Matsumoto (1996).

4.3. Cost and Nominal Commercial Event Predicates

We turn now from commercial event verbs to commercial event nouns. The problem of commercial event nouns is particularly interesting within the current framework since commercial event nouns can be denoting without entailing the existence of an actual commercial event. Thus, an item may have a price without ever actually being sold. Somehow, the word *price* must be tied to circumstances of circumstances without actually requiring the realization of a commercial event.

Prices seem to be dispositional properties, like the hardness and brittleness of materials. We cannot define the notions of brittleness or hardness without reference to the notion of breaking or scratching, yet objects can quite clearly be brittle without ever breaking. We may say that a material of a given brittleness has a given disposition to resist breakage. In the case of prices we may say an item has a disposition to sell at a certain price. The fact that it has the price does not mean that it has sold or will sell, or even that if it sells, it will sell at that price, but it means that, all things being equal, if circumstances continue to respect the current commercial constraints, it will sell at that price.

This sort of talk suggests that there is some kind of modality in play here. The idea that covert modalities play a role in lexical semantics is not new but it is perhaps more pervasive. One place where recourse to modalities has arisen is in attempting to explain intensional objects. Thus, Quine (1960) suggests analyzing *seek* as *try to find* in an attempt to reduce *de dicto* readings of direct objects of *seek* to cases of taking narrow scope in an embedded propositional context. But even where non-specific readings do not come into play, notions of modality seem to play a role in word definitions. Conative/achievement pairs like *take/sit an exam* and *pass an exam* seem to be possible outcome/successful outcome pairs with no associated non-specificity. Words like *loan* and *owe* seem to entail obligations involving possession transfers. Objects of *owe* may be *de dicto*, but objects of *loan* cannot be, yet both words entail the same obligation to transfer possession of the loaned object.

To model these kinds of modalities, we extend our current notion of argument projection from the idea of a map between eventualities to the idea of a map between pairs, with each pair consisting of an eventuality and a world. Let us begin by letting *world* be a participant in the commercial event frame. The picture we want is roughly that a cost eventuality in world i is related to various *possible* commercial events in various worlds that respect the commercial constraints of i. In each of these worlds, the the *money* of the possible commercial event is equal to the *money* of the *cost* in i.

$$\begin{bmatrix} \textit{resource-consumption} & \\ \text{consumer} & \boxed{1} \\ \text{resource} & \boxed{2} \\ \text{resource-requirer} & \boxed{3} \\ \text{world} & \boxed{4} \end{bmatrix} \overset{\text{resource-consumption-inalienable-possession-}}{\mapsto} \begin{bmatrix} \textit{inalienable-possession} & \\ \text{rel} & \text{cost} \\ \text{instance} & \boxed{2} \\ \text{possessor} & \boxed{3} \\ \text{goal} & \boxed{1} \\ \text{world} & \boxed{5} \end{bmatrix}$$

We assume *cost* exploits the resource consumption subscene both as a noun and a verb. This means that non commercial event resource consumption verbs need to be able take the same valence as *cost*. The verb *lose* seems to be a good example:

(54) a. That car lost John \$3,000.
b. The car cost John \$3,000.
c. John lost \$3,000 on that car.
d. John spent \$3,000 on that car.

We assume that the mapping *resource consumption inalienable possession* has some special properties. First, as a pairwise relation on worlds and eventualities it is one-to one:

$$\text{commercial-event-inalienable-possession}: \mathbf{commercial\text{-}event} \times \mathbf{world} \longleftrightarrow \mathbf{inalienable\text{-}possession} \times \mathbf{world}$$

For any given possible worlds i, j, there is at most one commercial event in j that corresponds to and respects the commercial constraints of a cost eventuality in i. Thus, for a generalized modalized version of abstraction relations we may continue to claim they are one-to-one. The unary mapping for any world, w, however, is one-many:

$$\text{commercial-event-inalienable-possession}_w : \textbf{commercial-event} \times \textbf{world} \longleftarrow \textbf{inalienable-possession}$$

There are numerous worlds respecting the commercial constraints of a particular cost, in which the price is met.

The goal role in the argument structure for cost allows for the optional realization of the buyer in examples like the following:

(55) The cost of the item to the buyer is \$500.

4.4. Impingement

We turn to a second set of examples of participant projection, impingement verbs, called verbs of contact by impact in Levin(1993), listed under the *impact* and *cause-impact* frames in FrameNet.[26] Here we show how impingement verbs can be perspectivalized as directed motions. This will also provide an opportunity to give another example of a non participant argument, the *actor* in a causative valence.

The verbs in question fit into the following sentence contexts:

(56) a. The stick struck ∅ / against/ along the side of/ ? on the fence.
b. John hit the stick against/on/along the side of the fence.
c. John hit the fence with the stick.

Other verbs with more or less similar choices and meanings include *smash*,*bang*, *land*, *touch* . In projecting these contact or impingement verbs as directed motions and caused-directed-motions, we will be concerned only with the valences shown in (56a). The valence shown in (56c) will be dealt with in Section 6.

We assume the following circumstance frame:

[26] These verbs are discussed insightfully by a number of authors (Fillmore, 1967; Fillmore, 1976; Fillmore, 1977; Richardson, 1983; Guerssel et al., 1985, inter alia).

$$
\begin{array}{lll}
(57) & \text{sorts} & \textbf{impingement} \sqsubseteq \textbf{eventuality} \\
 & & \textbf{degree-of-force} \sqsubseteq \textbf{sort} \\
 & & \textbf{surface-type} \sqsubseteq \textbf{sort} \\
 & & \textbf{contact-type} \sqsubseteq \textbf{sort} \\
 & \text{impingement frame} & \begin{bmatrix} \textit{impingement} & \\ \text{rel} & [\,] \\ \text{impinger} & [\,\textit{entity}] \\ \text{contact-type} & [\,\textit{contact-type}] \\ & \\ \text{surface-type} & [\,\textit{surface-type}] \\ & \\ \text{degree-of-force} & [\,\textit{degree-of-force}] \\ \text{impingee} & [\,\textit{entity}] \end{bmatrix} \\
 & & \text{distinguisher}(\textit{contact-type}) \\
 & & \text{distinguisher}(\textit{surface-type}) \\
 & \text{hitting-contact :} & \textbf{contact-type} \mapsto \textbf{truth-values} \\
 & \text{striking-contact :} & \textbf{contact-type} \mapsto \textbf{truth-values} \\
 & \text{touching-contact :} & \textbf{contact-type} \mapsto \textbf{truth-values} \\
 & \text{air-to-ground-contact :} & \textbf{contact-type} \mapsto \textbf{truth-values} \\
 & \ldots & \\
 & \text{supporting :} & \textbf{surface-type} \mapsto \textbf{truth-values} \\
 & \text{nonhorizontal :} & \textbf{surface-type} \mapsto \textbf{truth-values} \\
 & \ldots &
\end{array}
$$

The *impingement* frame in(57a) has five participants. It describes circumstances in which one object, the impinger comes into contact with another, the impingee, with a degree of force.[27] *surface-type* and *contact-type* are attributes ineligible for projection. We propose *directed-motion* as the argument frame for the 2-argument impingement verbs, assuming the definition of Section 3 for the directed motion frame, repeated here:

[27] Positing the role *degree-of-force* will help capture the fact, illustrated in contrasts like

(i) The plane landed (*hard*) on runway 30.
(ii) The plane arrived (* *hard*) on runway 30.

that all these heads occur with adverbs like *hard*.

(58) sorts **directed-motion ⊑ motion**
motion ⊑ process

directed-motion frame
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{directed-motion}} \\ \text{rel} & [\,] \\ \text{theme} & \boxed{1}[\;\textit{entity}] \\ \text{goal} & \boxed{2}[\;\textit{entity}] \\ \text{resultant-location} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{location}} \\ \text{rel} & \text{location} \\ \text{figure} & \boxed{1}[\;\textit{entity}] \\ \text{ground} & \boxed{2}[\;\textit{entity}] \end{array}\right] \end{array}\right]$$

The participant projection, impingement-motion is given in (59) in AVM notation:

(59)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{impingement}} \\ \text{rel} & [\,] \\ \text{impinger} & \boxed{1}[\;\textit{entity}] \\ \text{impingee} & \boxed{2}[\;\textit{entity}] \end{array}\right] \underset{\mapsto}{\text{impingement-motion}}{}_{\sqsubseteq} \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{acquisition}} \\ \text{rel} & [\,] \\ \text{theme} & \boxed{1}[\;\textit{entity}] \\ \text{goal} & \boxed{2}[\;\textit{entity}] \end{array}\right]$$

This makes possible the following lexical axiom for a basic impingement verb like *hit*:[28]

(60) $\text{hit} = \text{impingement} \circ \text{impingement-motion}^{-1}$

For the 3-argument impingement verbs using the valence illustrated in (562) we first need to introduce the following 3-argument frame.

(61)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{simple-action}} \\ \text{causer} & \boxed{1} \\ \text{sa-theme} & \boxed{2} \\ \text{process} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{process}} \\ \text{figure} & \boxed{2} \end{array}\right] \end{array}\right]$$

[28] For impingement verbs that encode extra information besides impingement, the lexical axiom needs to include specialized attribute information. For example:

$\text{land} = \text{air-to-ground-contact} \circ \text{contact-type} \circ \text{impingement-motion}^{-1}$

This frame involves an actor causally connected to a process. There is also a theme whose connection to the process is left unspecified in this frame. This frame will serve as argument frame for a number of agent controlling process that does not necessarily lead to change in the theme:

(62) a. John ironed the clothes.
 b. John heated the beans. (non-telic-reading)
 c. Fred kneaded the taffy.

Given the simple action frame, we can capture the meaning of the 3-argument valence of of *hit* used in (56b):

(63) $\text{hit}/3_{\text{against}} = \text{hit}/2 \circ \text{process}_{\sqsubseteq}$

Given the definition of $\text{hit}/3_{\text{against}}$ in (63), we can represent $\text{hit}/3_{\text{against}}$ in attribute-value format as a simple action in which the process has been specialized to be a directed motion of which hit/2 is true.

(64)
$$\begin{bmatrix} \textit{simple-action} & \\ \text{rel} & \text{hit}/3_{\text{against}} \\ \text{actor} & \boxed{1} \\ \text{theme} & \boxed{2} \\ \text{process} & \begin{bmatrix} \textit{directed-motion} & \\ \text{rel} & \text{hit}/2 \\ \text{theme} & \boxed{2} \\ \text{goal} & \boxed{3} \end{bmatrix} \end{bmatrix}$$

Note that what (63) does is define one lexical predicate in terms of another, and in fact, both concepts are expressed with the same pronunciation *hit*. Thus we will call this a sense transfer axiom.

Axiom (63) has certain features special to sense transfer axioms. Note for example, that in this case we needed to define no special-purpose abstraction relation. The language provided one for us in the form of the *process* role in the argument frame. Thus in defining an argument frame with an eventuality role *process*, we also defined the necessary relation and participant projections between a *simple-action* eventuality and a *directed-motion* eventuality.

Thus an analogy can be drawn between certain cases of sense transfer and participant projection. Just as commercial events can be viewed as acquisitions of goods, so certain landings can be viewed as caused events. In sense transfer the input to the perspectivalization process is a lexical predicate; in participant projection it is a circumstance frame. But in the system laid out here, circumstance frames and lexical predicates are the same kinds of formal objects. Both and circumstance frames and lexical predicates are defined through sortal predicates with eventuality arguments. It is true that a participant is added in using the simple-action frame for projection, but as we have seen with *spend* this may also happen in participant projection.

The kind of sense transfer illustrated in (63): embodies what we call circumstance-preserving sense transfer: The derived meaning *land/3* can be viewed simply as the simplex meaning *land/2* composed with a certain "coercion function".[29]

We repeat here the lexical axiom for *buy*:

---

[29] Formally, the sense transfer axiom is just an axiom relating two predicates and requiring their denotations to stand in a certain relation. To guarantee they belong to words that are pronounced the same we need some other device, like the "syntax" rules of Dowty (1979). We leave that device open here, because in principle, the work here is compatible with either a lexicalist or a non lexicalist approach to the sense transfer. In a lexicalist account, we would assume a meaning relation:

$$[\![\bullet]\!]$$

which relates expressions and meanings.

$$[\![\bullet]\!](\alpha, \beta)$$

means that expression α has meaning β. Then a lexical sense transfer rule would say something like:

> For all words α, if $[\![\bullet]\!](\alpha, \beta)$ and $\beta \circ \text{process}$ is defined, then $[\![\bullet]\!](\alpha, \beta \circ \text{process})$.

The form of such sense transfer rules is: if meaning 1 is defined for α, then if meaning 2 is defined, then meaning 2 is defined for α. We discuss sense transfers that aren't fully productive in Section 10. There are myriad ways in which something with the same semantic effect could happen in the syntax. When the coercion relation is a subscene relation like process, then some functional head could project the extra structure. See Tenny (2000) for an account along these lines, using lexical decompositions quite similar to those advocated here. Coercions that do not involve subscene relations are discussed in Section 6. It is less obvious how such coercions could perspicuously be accounted for in the syntax.

(65) buy = commercial-event $\circ$ goods-acquisition^{-1}

There are some striking similarities between this axiom and (63). In each case there is a function, f, relating two "frames", goods-acquisition^{-1} in (65), *process* in (63). Call this f the **coercion function**. What makes each f a good coercion function is that it brings with it a participant projection. In the case of *goods-acquisition* this was done through the participant projection axioms in (38). In the case of *process* this was done in defining the *directed-motion* frame.

We return to the subject of sense transfer relations at greater length in Section 6.

The definition of the *simple-action* frame in (61) constitutes the first attempt in this work to introduce actions with complex substructures. Figure 1 introduces a simple hierarchy of complex actions to put this idea into some context.

In addition to simple actions, there are actions belonging to two new frames, *change* and *resultative-action* The frame resultative action inherits from both *change* and *simple-action*. Conversely, a simple-action can be viewed as a resultative active minus the result, and a change as a resultative action minus the actor.[30] Examples requiring change eventualities are simple two-participant changes of state without an actor:

(66) a. The vase broke into pieces.
b. The hammer broke against the vase.

The resultative action frame is a very general frame with two subscenes, a process which plays some causal role together with a result, which is generally telic (though we will not directly address that issue here).

(67) John broke the hammer against the vase.

This intuition follows a number of authors(McCawley, 1968; Carter, 1988; Dowty, 1979; Stechow, 1995). As we will see, heads may conflate with either the process or the result role in lexicalization.

[30] Indeed, the argument structures in Figure 1 optional roles, *actor* and *result*. Formally, in terms of the axioms, the difference between these two descriptions appears to amount entirely to what sorts are mentioned in axioms. For expository purposes, if nothing else we have chosen the description which is easier to talk about.

$$\begin{bmatrix} \textit{simple-action} & \\ \text{actor} & \boxed{1} \\ \text{theme} & \boxed{2} \\ & \\ \text{process} & \begin{bmatrix} \textit{process} & \\ \text{p-theme} & \boxed{2} \end{bmatrix} \\ & \end{bmatrix}$$

$$\begin{bmatrix} \textit{change} & \\ \text{theme} & \boxed{2} \\ & \\ \text{process} & \begin{bmatrix} \textit{process} & \\ \text{p-theme} & \boxed{2} \end{bmatrix} \\ & \\ \text{result} & \begin{bmatrix} \textit{telic-process} & \\ \text{s-theme} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

$$\begin{bmatrix} \textit{resultative-action} & \\ \text{actor} & \boxed{1} \\ \text{theme} & \boxed{2} \\ & \\ \text{process} & \begin{bmatrix} \textit{process} & \\ \text{p-theme} & \boxed{2} \end{bmatrix} \\ & \\ \text{result} & \begin{bmatrix} \textit{telic-process} & \\ \text{s-theme} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

Figure 1. Action-Change Hierarchy

What the simple-action frame is a frame in which an agent is causally implicated in process which may or may not be telic.. We distinguish that case from the case in which there are three components, an actor, a process, and a result, which have called **resultant actions**. For example, in the case of hit/3 in (56b), we have a simple action: the process is a directed motion; the actor is directly involved in causing that process by manipulation. There are other uses of *hit* in which that impingement action in turn results in a directed motion event:

(68) a. John hit the bat against the wall. (simple-action; **process** $\sqsubseteq$ **directed-motion**)
b. John hit the ball over the fence. (resultant-action; **process** $\sqsubseteq$ **directed-motion**, **result** $\sqsubseteq$ **directed-motion**)
c. John broke the hammer against the vase. (resultant-action; **process** $\sqsubseteq$ **directed-motion**, **result** $\sqsubseteq$ **shape-change**)

In (a) John manipulates the bat while it hits the wall. In (b), he hits it and that causes it to go over the fence. In (c), he hits a vase with a hammer and that causes it toreak. The contrast between simple action and resultant action, then, is the contrast between a simple action and a action with an expressed result. In one form or another, some distinction between these cases has been assumed by many authors. Most previous authors have assumed that this requires a contrast between impingements and directed-motions. I assume that impingements are a variety of directed motion and that the contrast can be accounted for in the nature of the actor's involvement.

The chief advantage of claiming that impingements are directed motions is in the account of the preposition marking, where locative prepositions are used. We turn to that account in the next section.

4.5. Preposition Meanings

A remaining question about impingement verbs is preposition selection. In fact only a small set of prepositions is allowed with the impingement verbs in the valence illustrated in (56b):

(69) a. John hit the stick against/along/on the fence.
b. John hit the ball over the fence.

In (69a), the fence is *impingee*, the stick an implement delivering the blows. In (69b) the *ball* is impingee and *over the fence* a path modifier. The example in (69b) belongs to a sense of *hit* we call the caused-motion sense, which will be discussed in Section 6. The impingement sense is restricted to a small class of prepositions involving surface to surface contact.

We propose that prepositions like *against* are predicates on a *location* subscene abstracted out of an impingement. The subscene must determine the location of the *impinger* with respect to the impingee at the moment of contact. We begin with a new abstraction relation and its role equations

$$\begin{bmatrix} \textit{impingement} & \\ \text{rel} & [\,] \\ \text{impinger} & \boxed{1} \\ & \\ \text{impingee} & \boxed{2} \end{bmatrix} \xrightarrow[\sqsubseteq]{\text{impingement-location}} \begin{bmatrix} \textit{location} & \\ \text{rel} & [\,] \\ \text{figure} & \boxed{1} \\ & \\ \text{ground} & \boxed{2} \end{bmatrix}$$

We require not just that this subscene abstract out a location, but that it be a very particular location, namely the resultant location of the directed motion abstracted out by impingement-directed-motion. This can be done with following role equation:

$$\textit{resultant-location} \circ \text{impingement-motion} = \text{impingement-location}$$

In general preposition meanings are more complex than verb meaning because they need to define relations between eventualities and individuals, where verbs define a sortal predicate on eventualities. We want locative prepositions like *against* to be associated with a roles of a location eventuality, but we also need to restrict the eventuality further.

We define the meaning of the preposition *against* in two steps. First we define a predicate $\text{against}_{\text{imp}}$ that restricts the class of locations to impingement location eventualities with a certain feature:

$$\text{against}_{\text{imp}} = \text{supporting} \circ \text{surface-type} \circ \text{impingement-location}^{-1} \circ$$

This is a predicate defined only for location eventualities related to impingements, and true only of those in which the surface is supporting. Then one sense of the preposition *against* is:

(70) $[\![\text{against}]\!] = \lambda x, e[\text{against}_{\text{imp}}(e) \wedge \textit{ground}(e) = x\,]$

This is a relation between an entity x and locations l such that l is in the range of the *impingement-location* mapping and l's *ground*(*impingee*) is x.

There is another largely equivalent treatment which is more in line with the "ideal meaning" program of Herskovits (1986). This is to posit an argument frame against which inherits from location, which functions as the ideal meaning of *against*, specializing within each set of circumstances:

$$\textbf{against} \sqsubseteq \textbf{location}$$
$$\begin{bmatrix} \textit{against} & \\ \text{rel} & [\,] \\ \text{against-figure} & \textbf{entity} \\ \\ \text{against-ground} & \textbf{entity} \\ \\ \text{support-type} & \textbf{partial} \end{bmatrix}$$
$$\textit{against-figure} :== \textit{figure}$$
$$\textit{against-ground} :== \textit{ground}$$
$$[\![\text{against}]\!] = \lambda x, e[\text{impingement-location}^{-1}(e) \wedge \textit{against-ground}(e) = x\,]$$

We define the relation *against* as a location relation in which there is contact between figure and ground and the ground offers partial support to the figure. The claim is that these features are common to all the meanings of *against* and will be further instantiated from circumstance to circumstance. The claim is also that these features will never be overruled, at least if the entailment principle is correct.

We will not adopt ideal meanings as parts of lexical entries here. We assume that there will be a variety of circumstance-specific lexical entries for *against*. In Section 10 we argue that ideal meanings in the sense of Herskovits are best thought of as part of the evaluation measure of the lexicon, as argued for the case derivational alternations by Bochner (1993). That is, they are patterns which can be used to license or partially license lexical entries, lessening their cost. Our point here is simply to note that such a move seems entirely in the spirit of the divide between circumstances and argument structure assumed here.

4.6. Instrumental With

Another example will be useful for comparison and to facilitate discussion of valence alternations in Section 6.

Instrumentals will be analyzed as marking an eventuality role called *process*, exploiting that very general eventuality sort **process** already seen in defining directed motions. An instrumental process will be associated with one entity, an *instrument*, acting on another an *undergoer*. Again, a different abstraction relation is needed because a new argument frame being used for projection:

(71) **instrument-use $\sqsubseteq$ process**

$$\begin{bmatrix} \textit{impingement} & \\ \text{impinger} & \boxed{1} \\ & \\ \text{impingee} & \boxed{2} \end{bmatrix} \xrightarrow[\text{impingement-instrument-use}_{\sqsubseteq}]{} \begin{bmatrix} \textit{instrument-use} & \\ \text{instrument} & \boxed{1} \\ & \\ \text{undergoer} & \boxed{2} \end{bmatrix}$$

$[\![\text{with}]\!] = \lambda x, e[\,\textit{instrument}(e) = x\,]$

Note that in this case the object of the preposition is associated with the *impinger*.

Again as in all projections, truth-conditional relations are being preserved. A process is just a two-participant eventuality in which one entity acts against another. The intuition axioms (a), (b), (c) capture is that an impingement can be viewed as such a situation and when it is, the impinger is the instrument and the impingee the undergoer. The claim is that this ultimately is what licenses *with* to be used to mark the impinger with impingement verbs.

What (71) does is license a meaning of instrumental *with* as a marker of the impinger in an impingement. Of course, instrumental uses of *with* occur in contexts other than impingement verbs, and without any entailment that the instrument moves:

(72) a. He bribed the guard with a $20-bill.
b. He stopped the leak with a wad of chewing gum.
c. The soprano broke the glass with a high C.

The idea is to analyze these cases, as well, as different senses related to a single ideal meaning. Each of these will relate the argument-frame *instrument-use* to a different set of circumstances, all realized with the preposition *with*. Each will require a different abstraction relation with a different set of circumstances as its domain and instrument uses as its range.

4.7. Verbs of Shape Change/Loss

To maximize points of comparison between the approach pursued here and other approaches to lexical semantic description, we briefly discuss one of the most-discussed verb classes of all time, verbs of shape change. These verbs also play a role in the discussion of valence change in Section 6, in particular, the following facts will be of interest (Fillmore, 1967).

(73) a. John broke the vase with the hammer.
b. John broke the hammer against the vase.
c. John cooled the soup against/on the ice.
d. John spilled the milk against the pan. [from INTRO]

The instrumental valence in (73a) is shared by a large group of action verbs; however the valence in (73b) is much more constrained. What is conveyed is that the hammer's moving against the vase is what causes it to break, despite the fact that *break* is a verb that seems to encode no intrinsic movement. This movement-caused state change entailment applies only state change verbs that have to do with change or loss of shape or deformation: *break*, *chip*, *crack*, *flatten*, *shatter*, *smash*, *split*, *dent*,*crunch*, and *crumple*. This is shown by 73c) and (73d). Example (73c) cannot mean that John caused the soup to cool by moving it against or on the ice. Example (73d), discussed in the introduction, cannot mean that moving the milk against the pan caused it to spill. These facts are clearly anchored in the circumstances the verbs describe, depending on how naturally a movement event may be causally connected with the state change, as emphasized in Gawron (1986).

We deal explicitly with these valence facts in Section 6. Here we propose a circumstance frame for *shape-loss*, and show the argument frame for the simplest case. The circumstances:

$$\begin{bmatrix} \textit{shape-loss} & \\ \text{state-bearer} & [\ \textit{entity}] \\ & \end{bmatrix}$$

$$\textbf{broken} \sqsubseteq \textbf{shape-loss}$$
$$\textbf{shattered} \sqsubseteq \textbf{shape-loss}$$
$$\textbf{dented} \sqsubseteq \textbf{shape-loss}$$

This is a simple frame describing a single entity in a shape loss state. Rather than decompose the state into constituents, we have identified the various kinds of shape losses simply as specializations of the basic frame.

We use *break/1* for the semantics of the verb in:

(74) The vase broke.

For this verb and a class of state change verbs like it, we follow a number of authors (Chafe, 1970; McCawley, 1968) in positing an argument frame that consists of a simple state change relation, with a role *end-state* filled by an entity of sort state.

$$\textbf{state-change} \sqsubseteq \textbf{process}$$
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{state-change}} \\ \text{sc-theme} & \boxed{1} \\ & \\ \text{end-state} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{state}} \\ \text{theme} & \boxed{1} \end{array}\right] \end{array}\right]$$

We assume that the participant projection of shape loss maps directly to the argument frame *state*, which is a subscene of *state-change*:

$$\left[\begin{array}{ll} \multicolumn{2}{l}{\textit{shape-loss}} \\ \text{state-bearer} & \boxed{1} \\ & \end{array}\right] \overset{\text{shape-loss-state}}{\longrightarrow} \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{state}} \\ \text{theme} & \boxed{1} \end{array}\right]$$

This now allows us to use *end-state*, the subscene relation in this frame, to define verb senses for state change verbs. For example, we assume the following lexical axiom for *break*/1:

$$\text{break/1} = \text{broken} \circ \text{shape-loss-state}^{-1}\ \textit{circend-state}$$

Thus, *break/1* is true of a state change whose resultant state is a broken state.

In many respects this analysis is simply a re-encoding of previous analyses of state-change verbs into the present framework (McCawley, 1968; Carter, 1988; Dowty, 1979; Levin and Rapoport, 1988; Hale and Keyser, 1993; Parsons, 1990; Tenny, 2000).

4.8. Verbs of Cutting, Sharpening, Rattling, Scraping

As noted in Fillmore (1977), the case of the verb *cut* is interesting to compare with *hit* and *break*:

(75) a. John cut his foot on a rock.
b. John cut his foot with a rock.

Like *break*, *cut* involves a state change, and like *break* the theme, the object whose state changes, remains direct object whether *with* or *on* is used.[31]

The difference, however, is that cutting involves two participants, a sharp thing and the entity cut. As noted by Guerssel (1985), this can be related to the absence of an intransitive version of *cut*:

(76) * John's foot cut.

It seems reasonable based on the state change, to relate *cut* to a specialization of shape change involving two participants. Since cutting always involves one object moving against another, one might also be tempted to make those circumstances a specialization of impingement, but this would be problematic. The sentences in (75) show that, although movement is necessary for cutting, it is not decided in advance which participant does the moving. It would be somewhat peculiar to make a frame inherit from *impingement* without determining who was impinger and who was impingee. Additionally, *cut* does not co-occur with *hard* like other impingement verbs:

(77) # John cut the steak hard.

Therefore we propose simply to assimilate *cut* to a version of shape change:

$$\textbf{surface-division} \sqsubseteq \textbf{state-change}$$
$$\begin{bmatrix} \textit{surface-division} & \\ \text{sharp-implement} & \boxed{1} \\ & \\ \text{state-bearer} & \boxed{2} \end{bmatrix}$$

In order to have an account of the unacceptability of (76), we need an account of when participants can be left out of participant projection, That account was presented in Section 4.1.

A core circumstantial participant can be left out of participant projection only if some subscene relation abstracts out a subscene

[31] This verb is illuminatingly discussed in a number of places (Fillmore, 1976; Guerssel et al., 1985; Gawron, 1986; Hale and Keyser, 1986; Hale and Keyser, 1987).

excluding that participant. Thus, the seller was left out with *spend* because there was a resource-consumption subscene of a commercial event. In this case no such subscene can be abstracted out and the sharp implement must be realized. But as yet the participant projections of *shape-loss* have made no provisions for a second participant. Nevertheless, we know there can be second and even third participants with verbs of state change in examples like (73) and (75). We turn to the problem of accounting for these other participants in Section 6.

4.9. Formal Definition of Circumstances

This section is rather technical and may be skipped by the reader interested in the main thread of the argument but less interested in the technical details.

The goal here is to propose a formal definition of circumstance for all lexical senses. More specifically, for each lexical predicate, we will define unique companion predicates, the argument frame predicate and the circumstance predicate.

We begin by assuming a set of circumstance frames Circ and a set of argument frames AF. By frames we meet predicates typed for roles in our logical language. We assume that

$$\mathrm{AF} \subseteq \mathrm{Circ}.$$

We assume corresponding sets of sorts $\mathrm{Sort}_{\mathrm{AF}}$ and $\mathrm{Sort}_{\mathrm{Circ}}$ also standing in a subset relation:

$$\mathrm{Sort}_{\mathrm{AF}} \subseteq \mathrm{Sort}_{\mathrm{Circ}}.$$

We assume a function Pred, from sorts to predicates relating the predicate domains to the sort domains.

$$\begin{array}{l} \mathrm{Pred}_{\mathrm{AF}} : \mathrm{Sort}_{\mathrm{AF}} \longrightarrow \mathrm{AF} \\ \mathrm{Pred}_{\mathrm{Circ}} : \mathrm{Sort}_{\mathrm{Circ}} \longrightarrow \mathrm{Circ} \end{array}$$

When the context makes it clear, we will omit the subscript on Pred.

We also assume a core set of abstraction relations, each of which maps from some sort in $\mathrm{Sort}_{\mathrm{Circ}}$ to some sort in $\mathrm{Sort}_{\mathrm{AF}}$. Thus far, the members of AR we have introduced are:

goods-acquisition
goods-giving
resource-consumption
impingement-directed-motion
impingement-location

We also introduce a set of argument frame subscene relations, all of which have argument frame sorts as their domain and range. We call this set Subscene. All subscene relations $R_{\sqsubseteq}$ satisfy the following conditions:

(a) $R_{\sqsubseteq} : \sigma \longrightarrow \tau$;
(b) $\sigma, \tau \in \mathrm{Sort}_{\mathrm{AF}}$;
(c) $R_{\sqsubseteq}(e_1, e2)$ entails that e_1 is a subscene of e_2.

Examples of Subscene are resultant-location . . .

We define AR*to be the closure of AR $\bigcup$ Subscene under function composition and inverses:

(a) If $R \in AR \bigcup$ Subscene then $R \in AR^*$;
(b) If $R \in AR \bigcup$ Subscene then $R^{-1} \in AR^*$;
(c) If R_1, $R_2 \in AR^*$ then $R_1 \circ R_2 \in AR^*$;
(d) AR^* is the smallest set satisfying (a) through (c).

We define Circs as follows;

Definition of Circumstances

Let P be a lexical predicate such that

(a) $P = P_{\mathrm{circ}} \circ \Pi$, where
(b) $\Pi \in AR^*$;
(c) $\Pi : \sigma \longrightarrow \tau$;
(d) $\mathrm{Pred}(\sigma) \in AF^*$;
(e) $\mathrm{Pred}(\tau) \in \mathrm{Circ}$;
(f) σ is the most specific sort satisfying (a) through (e).

Then we will write $\mathrm{Circ}_{\mathrm{P}}$ (circumstances of P) for $\mathrm{Pred}(\sigma)$, and AF_{P} (argument frame of P) for $\mathrm{Pred}(\sigma)$

We give three examples:

1. *Buy*:

   $$\begin{array}{l}\text{buy} = \text{commercial-event} \circ \text{goods-acquisition}^{-1}\\ \text{buy} : \textbf{acquisition} \longrightarrow \textbf{commercial-event}\\ \text{Pred}(\textbf{acquisition}) = \text{acquisition} \in \mathbf{AF}\\ \text{Pred}(\textbf{commercial-event}) = \text{commercial-event} \in \mathbf{Circ}\end{array}$$

   Therefore commercial-event is the circumstance predicate of *buy* and acquisition is the argument frame predicate.

2. land/2:

   $$\begin{array}{l}\text{land/2} = \text{air-to-ground-contact} \circ \textit{contact-type} \circ \text{impingement-motion}^{-1}\\ \text{impingement-motion} : \textbf{directed-motion} \longrightarrow \textbf{impingement}\\ \text{Pred}(\textbf{directed-motion}) = \text{directed-motion} \in \mathbf{AF}\\ \text{Pred}(\textbf{impingement}) = \text{impingement} \in \mathbf{Circ}\end{array}$$

   Note that in this case when we factor the lexical predicate into two parts, the predicate part is complex.

   $$\text{air-to-ground-contact} \circ \textit{contact-type}$$

   is the $\mathrm{P}_{\mathrm{circ}}$ of the definition, and is a property of impingements. Therefore impingement is the circumstance predicate of land/2 and directed-motion is the argument frame predicate.

3. land/3:

   $$\begin{array}{l}\text{land/3} = \text{air-to-ground-contact} \circ \textit{contact-type} \circ \text{impingement-motion}^{-1} \circ \textit{process}\\ \text{impingement-motion} \circ \textit{process} : \textbf{simple-action} \longrightarrow \textbf{impingement}\\ \text{Pred}(\textbf{simple-action}) = \text{simple-action} \in \mathbf{AF}\\ \text{Pred}(\textbf{impingement}) = \text{impingement} \in \mathbf{Circ}\end{array}$$

   Note that in this case when we factor the lexical predicate into two parts, the abstraction relation part is complex.

   $$\text{impingement-motion} \circ \textit{process}$$

   is the Π of the definition. Note, however, that it is still a mapping to impingements. Therefore impingement is the circumstance predicate of land/3, just as it is for land/2, but simple-action is the argument frame predicate.

5. Valence Theory

In this section we propose to say a bit more about the set of argument frames for English and about the valence theory.

A valence theory for a language should account for the following:

1. the realization of arguments as nuclear terms (the so-called *linking theory*)

2. the realization of arguments as obliques

3. the realization of arguments as clausal complements

In this section we will discuss (1) and (2), which will suffice to nail down the general method, and leave (3) for future work.

We assume the arguments of a predicate must fill roles defined for a predicate, where roles are defined as in Section 2, as sortal domain and range restrictions on role functions (or role realtions, in the case of iterable roles such as *location*).

Thus any sort has a set of defined roles; and since every lexical predicate is assigned a sort through its argument frame, every lexical predicate has a set of assigned roles.

We can formulate the linking theory part of our theory of valence in a way compatible with previous work (Gruber, 1976; Fillmore, 1968; Ostler, 1979; Gawron, 1983; Levin, 1986; Carter, 1988; Jackendoff, 1990), making use of very general semantic notions (deep case roles or thematic roles) to state generalizations about how roles are realized as nuclear terms.

We assume basic argument structures like the following from Section 2:

$$\begin{bmatrix} \textit{act-th-go} & \\ \text{actor} & \textbf{animate} \\ \text{goal} & \textbf{animate} \\ \text{theme} & \textbf{entity} \\ & \end{bmatrix}$$

$$\begin{bmatrix} \textit{act-th-so} & \\ \text{actor} & \textbf{animate} \\ \text{source} & \textbf{animate} \\ \text{theme} & \textbf{entity} \\ & \end{bmatrix}$$

For concreteness, let us also assume the following hierarchy ordering some subset of basic roles:

$$\textit{causer} \geq \textit{actor} \geq \textit{theme}$$

Argument frames like *acqusition* and *donation* have roles identified with *actor* and *theme*. Here are the participant projections from Section 2, which identify the actor and theme:

$$\begin{bmatrix} \textit{possession-transfer} & \\ \text{donor} & \boxed{1} \\ \text{recipient} & \boxed{2} \\ \text{possession} & \boxed{3} \\ & \end{bmatrix} \xrightarrow{\text{acquisition}} \begin{bmatrix} \textit{act-th-so} & \\ \text{actor} & \boxed{2} \\ \text{source} & \boxed{1} \\ \text{theme} & \boxed{3} \\ & \end{bmatrix}$$

$$\begin{bmatrix} \textit{possession-transfer} & \\ \text{donor} & \boxed{1} \\ \text{recipient} & \boxed{2} \\ \text{possession} & \boxed{3} \\ & \end{bmatrix} \xrightarrow{\text{giving}} \begin{bmatrix} \textit{act-th-go} & \\ \text{actor} & \boxed{1} \\ \text{goal} & \boxed{2} \\ \text{theme} & \boxed{3} \\ & \end{bmatrix}$$

With the basic roles of an argument frame identified, the hierarchy may be used as follows. A role congruent with causer must be subject. A role congruent with actor must be subject, unless there is a causer present, in which case it must be direct object. A role congruent with theme must be subject, unless there is a causer or actor present, in which case it must be direct object. If there are no roles congruent with causer, actor or theme, then our linking theory has nothing to say about what becomes a nuclear term, except that we will assume that eventuality roles are not eligible to be nuclear terms.

We will use Langacker's term **profiled**(Langacker, 1991) to single out the lowest ranked term designated for nuclear termhood by the linking theory. Thus the term designated to be direct object in a transitive or subject in an intransitive.

We do not require that argument frames include a role congruent with causer, actor or theme. Thus we allow for the possibility that there are predicates for which the linking theory has nothing interesting to say. A candidate once mentioned by Paul Postal is the verb *outnumber*.

As an example, consider the verb *buy*, both of which utilize the argument frame *acquisition*. The participant projections for *acqui-*

sition make the acquisition recipient an actor and the acquisition possession a theme. The verb *buy* is defined as

$$\text{buy} = \text{commercial-event} \circ (\text{goods-transfer} \circ \text{acquisition})^{-1},$$

where the role projections for the goods transfer make the buyer the recipient. and the goods the possession. Therefore, the *buyer* is an actor for *buy* and the *goods* is a theme. They are predicted to be linked to subject and direct object respectively.

This leaves us with the case of non-nuclear modifiers. In general we assume modifiers can be construed as properties of eventualities. Consider a modifier $\mathcal{M}$ of this form:

$$\mathcal{M} = \lambda e r_1(e) = f$$

We will allow for two general cases:

1. Assume the head's eventuality is e'. The modifier meaning may be predicated directly of e'.

   $$\mathcal{M}(e')$$

   This is called **role application** and is defined only if r_1 is defined for the type of e'.

2. A modifier meaning may be interpreted by **coercing** the modifier meaning to fill a role of the head by composing it with some role r_2 defined for e':

   $$\mathcal{M} \circ r_2(e')$$

   This is called **role coercion**.

Non-nuclear term modifiers that yield well-defined semantics when combined by one of these operations with the head will be called **semantically compatible**.

We illustrate the simple case of role application:

The meaning of *from John* may be assumed to be:

(78) $\lambda e[\mathit{source}(e) = \text{john}]$

This is a role-filling property of an eventuality, that is, a function from eventualities to propositions that will only be well-defined if the eventuality is of a sort defined for the *source* role.

The meaning of *buy a book* may be assumed to be:

(79) $\lambda e, x \exists y[\, \mathrm{buy}(e) \wedge \mathit{buyer}(e) = x \;\wedge\; \mathit{goods}(e) = y \;\wedge\; \mathrm{book}(y)]$

Applying the meaning of *from John* to the eventuality of the head of *buy a book* gives us the meaning of *buy a book from John*.

This can be done by means of the following operator

$$\mathrm{Mod} = \lambda \mathrm{R}, \mathrm{M}[\lambda e, x[\mathrm{R}(e)(x) \wedge \mathrm{M}(e)]]$$

Then the semantic operation of combining a VP and a modifying VP will be:

$$\mathrm{Mod}([\![\mathrm{VP}]\!])([\![\mathrm{PP}]\!])$$

Applying this to (79), we have:

$$\lambda e \lambda x \exists y[\, \mathrm{buy}(e) \wedge \mathit{buyer}(e) = x \;\wedge\; \mathit{goods}(e) = y \;\wedge \\ \mathrm{book}(y) \wedge \mathrm{source}(e)(\mathrm{john})]$$

This is a standard modification operation, given a Davidsonian semantics.

Now why in particular is the *from*-phrase eligible to mark the seller participant for *buy*? The answer is straightforward. The *seller* for *buy* is projected as a *source*; *from*-phrases mark sources:

$$\begin{aligned} \mathit{seller} &= \mathit{donor} \circ \mathit{goods\text{-}transfer} \\ &= \mathit{source} \circ \text{acquisition} \circ \text{goods-transfer} \end{aligned}$$

Summing up what has been said, we have seen how the role constraints on an argument frame, taken together with some standard assumptions about a linking theory and semantic composition, can be used to constrain (though possibly not to predict) the valence of a verb. Thus far we have seen two ways a modifier can be realized as an argument. It can be realized as a nuclear term if the realized role is eligible for nuclear termhood or its marking can be semantically typed to realize a particular role of the head.

This leaves a large class of unmodifiers unaccounted for. We will discuss various kinds of adjuncts in Section 7. In the remainder of this section we discuss the remaining case of argument modifiers, those combined by role coercion.

Role coercion can be illustrated by means of locative modifiers. Again, we assume the meaning of a locative is simply a role predication.

(80) $\lambda e[\mathrm{in}(e) \wedge \mathit{ground}(e) = \text{New York}\,]$

We also assume the following role and relation axioms:

(a) $\mathit{location} : \mathbf{eventuality} \mapsto \mathbf{location}$
(b) $\mathrm{in} : \mathbf{in} \mapsto \mathbf{truth\text{-}values}$
(b') $\mathbf{in} \sqsubset \mathbf{location}$
(c) $\mathit{ground} : \mathbf{location} \mapsto \mathbf{entity}$

Axiom (a) says that location is a role for all eventualities. Axioms (b) and (b') require that the *in* relation be typed for *in*-sorted eventualities, and that an *in* is a subsort of *location*. Given these assumptions, the role *location* will be defined for *buy*. Axiom (c) defines the *ground* role for a location eventuality. Note that because*ground* is not a role of *buy*, the eventuality property in (80) can not directly be predicated of a *buy* eventuality. What can be done, however, is to make (80) a property of an eventuality that itself fills a role of *buy*.

The semantic operation is simply:

$$\mathrm{Mod}([\![\mathrm{VP}]\!])([\![\mathrm{PP}]\!] \circ \mathit{location})$$

This gives:

$$\lambda e \lambda x \exists y[\, \mathrm{buy}(e) \wedge \mathit{buyer}(e) = x \wedge \mathit{goods}(e) = y \wedge \mathrm{book}(y) \wedge \mathrm{in} \circ \mathit{location}(e)(\text{New York})]$$

The possibility of role coercion depends on the existence of a head role defined on an embedded eventuality and a modifier typed for that embedded eventuality. In this case, the head *buy* has a role defined on an embedded *location* eventuality and the modifier has a role *figure* defined for *locations*. What role coercion in effect does is use the *location* role as a coercion relation that maps from the inappropriate *buy* eventuality to a *location* appropriate for the modifier.

Note that the very fact that this is possible means that one could dispense with role coercion, in this case, simply by defining an *in* role directly for *buy*. But there are a number of reasons why role coercion is a desirable operation in the general case.

First, it provides a very natural means of applying frames to the analysis of prepositions and modifiers in general. When we can justify saying that a single role like *location* can be filled by a number of different types of modifiers, with different semantics, then we have some justification for an embedded eventuality, and we can posit that what unifies those modifiers is a single circumstance frame. In the case of locatives, that would be the *location* frame introducing a *figure* and *ground* role:

$$\begin{bmatrix} \textit{location} & \\ \text{figure} & \textbf{place} \\ & \\ \text{ground} & \textbf{entity} \end{bmatrix}$$

As discussed in Section 3.3, goal uses of locative prepositions, involve coercing locative meanings through a *resultant-location* role. These cases, then, will require role coercion by way of the *resultant-location* role rather the *location* role. For example, a preposition like *against* will now be assumed to have the meaning:

$$\lambda x, e[\text{against}(e) \;\wedge\; \textit{ground}(e) = x\,]$$

Note that the *ground* role is not directly a role of impingement verbs, which have *directed motion* as their argument frame. Thus, *against* needs to combine with an impingement verb like *land/2* with the following role coercion operation:

$$\text{Mod}([\![\text{VP}]\!])([\![\text{PP}]\!] \circ \textit{resultant-location})$$

Other prepositions that meet the location constraints in *impingement* are *on along the side of*.

Another use for role coercion is that it provides a natural way of describing adverbial and adverbial noun modification. As a simple case, consider the adverb *hard* which marks a degree of force. We might simply consider it a property of a degree of force:

$$\lambda x[\text{degree-of-force}(x) \;\wedge\; \text{high-degree-of-force}(x)]$$

This can be role-coerced to mark the degree of force role for an impingemnet verb.

Now in the case of adverbials like *hard* this analysis of course has a very natural competitor, one in which the denotation of the adverb is not a property of a degree of force but rather a role marker on exact analogy with the above treatment of source PPs:

$$\lambda e \exists x[\text{high-degree-of-force}(x) \;\wedge\; \textit{degree-of-force}(e) = x\,]$$

This meaning could be combined with a head by role application.

In the case of dedicated adjunct modifiers like *hard* there seems to be no independent argument deciding between these two denotations. But consider the case of NP adverbials, in particular, the distance modifiers licensed by the self-motion frame:

(81) John walked two miles.

If we assume that indefinites like *two miles* may be interpreted as properties of distances and that a walking eventuality has a role (*distance*) typed for distances, then the same role coercion operation that interprets locatives will interpret such NP modifiers:

$$\mathrm{Mod}(\mathrm{VP})(\mathrm{NP} \circ \mathit{distance})$$

The denotation of *two miles* on this analysis can be:

(82) $\lambda x\, \mathit{miles}(x) = 2$

This is just a property of distances true of those whose mile measure is 2[32]

Of course in this case too there is a competing analysis in which the modifier denotation can be directly combined with a verbal head by role application:

(83) $\lambda e \exists x[\mathit{distance}(e) = x \;\wedge\; \mathit{miles}(x) = 2$

But in this case there is an independent motivation favoring the denotation in (82) over the denotation in (83). The denotation in (83) builds in the role the phrase modifies. But *two miles* is an NP, which, like ordinary NPs, can fill a variety of roles:

(84) a. Two miles is a long distance.
b. Fred was silent for (the next) two miles.
c. Alice slowly worked her way up to two miles.
d. The two hundred miles that John ran that week was a personal record.

In examples (84a) through (84c), the phrase *two miles* shows up not as an adverbial but as a predicative NP or inside a prepositional phrase. In (84d) it functions simultaneously as an adverbial

[32] We assume units are just functions from measures to natural numbers. Thus the same distance can have mile measure 1 and foot measure 5,280.

(in the relative clause) and as a subject (in the matrix clause), strongly suggesting that one denotation type should handle both cases.

The denotation is (82) is, by assumption, the right type of denotation for an ordinary indefinite filling a non-eventuality role; it will apply to any suitably sorted role. The denotation in (83) is role-specific. In sum, providing for an operation of role coercion allows provides a natural device for allowing NP adverbials to be multi-functional without making them ambiguous.

As long as an NP adverbial denotes some type of eventuality for which the head has a defined role, then that role may serve as the coercion relation for interpreting the adverbial. In effect this is simply a variety of sort driven interpretation. Other cases of NP adverbials amenable to such sort-driven composition are shown in (85):

(85) a. John dances the way Mary dances. (manner adverbial)
b. We flew first class. (manner adverbial)
c. John drove 45 miles per hour.(speed adverbial)
d. John left that day (temporal adverbial)
e. John went to Boston three times. (event count adverbial)

Summing up, we have introduced a very basic valence theory that provides a foundation for discussing semantic compatibility of heads and modifiers. A verb is associated with an event sort chosen from limited language-particular inventory defined by the argument-frames, each of which is defined for an array of roles. The roles are implicitly ordered by the linking theory. Roles may either be realized as nuclear terms if the linking theory allows or some oblique marking must be found, again from a limited inventory of oblique markers the language offers. In that case the role is marked either by role application or role coercion.

What the valence theory tells us is, given a head and the argument frame it projects into, what its possible modifiers are. This leaves one large question about which we have as yet said nothing explicit. What licenses a particular argument structure to realize a particular head with a particular role projection?

The valence theory has little predictive force if the circumstance frame for *break* can project the *breaker* into the *theme* role and the *broken* into the *actor* role.

The required principle is, intuitively, a particular entailment relation among the frame types. To define this we need the notion of a *role binding*, a (possibly partial) function from the participant relations of the circumstance frame c to the roles of the argument frame a. We represent this as a function that takes a sequence of participant relations of c and returns a sequence of roles of a. We write:

$$b(\overline{r})$$

for the result of applying role binding b to participant $\overline{r}$. That result is a role sequence. We write:

$$\overline{r}(\overline{x})$$

for the result of applying role sequence $\overline{r}$ to sequence $\overline{x}$. That result defines an eventuality property we write:

$$[\overline{r}(\overline{x})]$$

For a role sequence $\overline{r}$, $r_1 \ldots r_n$ and a sequence $\overline{x}$, $x_1 \ldots x_n$,

$$[\overline{r}(\overline{x})] = \lambda e[r_1(e){=}x_1 \ \wedge \ r_2(e){=}x_2 \ \wedge \ \ldots r_n(e){=}x_n \ \wedge]$$

The implicit principle is, intuitively, the following:

> A circumstance frame **c** projects into an argument frame **a** under a role binding **b** if and only if for every instance c_i of **c** such that $[\overline{r}(\overline{x})](c_i)$ there is an instance a_i of **a** such that $[\mathbf{b}(\overline{r})(\overline{x})](a_i)$

That is, the existence of an instance of **c** described by $\overline{r}(\overline{x})$ entails the existence of an instance of **a** described by $\mathbf{b}(\overline{r})(\overline{x})$.

Illustrating this, the commercial event may be projected into an acquisition with the buyer mapped to recipient, the goods mapped to theme, and the seller mapped to acquistion-donor if and only if for every commercial event with buyer equal to x, goods equal to y, and seller equal to z there is an acquisition in which the recipient is x, the theme is y and the donor is z. Now this is just what the abstraction axioms in (38) do. Notice that these axioms make a real entailment claim about commercial events. They say that every commercial event entails a possession transfer in which the buyer acquires the goods from the buyer. And the entailment principle says that it is this fact which licenses *buy* to have the same valence pattern as *acquire*. Note that the entailment holds not between verbs but between circumstances and argument frames; that is, the claim is that the circumstances entail a certain abstract semantic relation among the participants shared by all the verbs with that valence.

This, then is really just making explicit what is meant by a semantic theory of valence. Abstraction axioms are statements of the logical relations between circumstance and argument frames that license particular valences.

6. Valence Alernation

In this section we sketch an approach to the problem of valence alternation in English, developing the example of the verbs of hitting and breaking discussed in Section 4.4. The larger question here is the sources of argument structures that do not match the core circumstantial participants of a head. Thus, all of the alternative valences discussed in this section are cases in which there is a mismatch between the set of argument structure roles in an alternative valence and the set of core participants in the associated with a verb. In particular, the argument structure has an extra role, an actor with verbs of hitting, a theme or a goal with the verbs of breaking.

We argue that these cases are best accounted for by sense transfer rules. First, sense transfer is a natural mechanism with which to account for new valences in a theory in which valences are supposed to be predictable (or at least partly predictable) from senses. Second, we argue for a constrained theory of sense transfer coercions, much in the spirit of Pusteyovsky (1995), but with a somewhat different agenda.

6.1. Hitting and breaking

In this section we extend the analysis of impingement and breaking.

We deal with the following valences:

(86) a. The stick hit the fence.
b. John hit the stick against the fence.
c. John hit the fence with the stick.
d. John hit the ball over the fence.
e. The vase broke.
f. The vase broke against the hammer.
g. John broke the vase against the hammer.
h. John broke the hammer with the vase.

The challenge is to show how a single set of circumstances is related to all the valences while capturing the generalizations about these sense transfers and the differences in meaning.

The alternation between (86a) and (86b) has already been discussed in Section 4.4, where we argued that the sense of *hit* in

(86b) could be defined in terms of the sense in (86a) through a sense transfer.

(87) $\text{hit}/3_{\text{against}} = \text{hit}/2 \circ \text{process}$

We briefly summarize the mechanisms invoked to associate this sense with the correct valence. Observe that $hit/3_{against}$ is a predicate true of simple-action eventualities, namely those whose processes are instances of *hit/2*. Being a simple action, the eventualities $hit/3_{against}$ is true of will be defined for actors and themes, which according to the valence theory of Section 5, must be realized as subject and object respectively.

The use of *against* to mark the impingee will also be licensed, given the meaning of *against* introduced in Section 4.4. That meaning is defined for eventualities of the sort

$$\text{location}_{\text{impingement}},$$

precisely those *hit/2* assigns to its resultant location role. Thus, an *against*-PP will be semantically licensed if it is combined with the coercion

$$\text{Mod(VP)}(\text{PP}_{\text{against}}) \circ \textit{resultant-location} \circ \textit{process}$$

Observe that

$$\textit{resultant-location} \circ \textit{process} \in \text{AR}^*$$

as required by the Coercion Principle of Section 5. Recall that the relation-set AR*was defined in Section 4.9 as the closure of the set of abstraction relations and subscene relations under inverses and compositions. Since both *resultant-location* and *process* are subscene roles, their composition is in that closure.

Paralleling the coercion principle, we assume the following general **Sense Transfer Principle**.

Sense Transfer Principle

If a word **W** has a sense α, then if κ is a sense transfer function of the grammar, then **W** may also have sense β, where

$$\beta = \alpha \circ \kappa$$

As a preliminary condition on sense transfer coercions let us try:

$$\kappa \in \mathrm{AR}^*$$

Consider our first example, the sense transfer in (87). The relation κ here, which we will call the sense transfer coercion, is *process*. *process* is a subscene role; therefore it is in AR*; therefore this sense transfer is licensed.

Note that not every member of AR*can be a valid sense transfer coercion. Consider the case of the Dative alternation and the verb *spend*. Following Goldberg (1995), we hypothesize as a preliminary (and incomplete) constraint on the dative sense transfer is that it apply to verbs with argument frames that entail possession transfer. *Acquisition* and *donation* are such argument frames because they are directly defined as projections of possession transfer. But resource-consumption is defined in terms of resource consumption circumstances and does not entail possession transfer. Thus even though *spend* entails possession transfer (it is associated with the money transfer of a commercial event), its argument frame does not. But there is a relation in AR*that would coerce *spend* into a possession transfer verb, namely:

$$\text{donation} \circ \text{resource-consumption}^{-1}$$

Thus AR*has too much in it to offer a sufficiently constrained account of all sense transfers.

The leaves the set of valences in (86c-h) to be accounted for. We begin with the valence in (86c). Consider using the same sense for (86c) The argument frame is simple action and the head verb eventuality fills the process role for this valence as well. as was used for (86b).

This meaning is shown in (64). Note that this sense is incompatible with the preposition *with*, in the sense introduced in Section 4.4, because there is no eventuality role typed for instrument uses. Thus, this sense will not account for the valence in (86c).

To account for that valence we will need a new coercion:

(88) $$\begin{bmatrix} \textit{instrument-use} & \\ \text{instr} & \boxed{1} \\ \text{underg} & \boxed{2} \end{bmatrix} \xrightarrow[\text{instrument-use-process}]{} \begin{bmatrix} \textit{directed-motion} & \\ \text{theme} & \boxed{1} \\ \text{goal} & \boxed{2} \end{bmatrix}$$

This declares a new coercion relation, instrument-use-process, to be a mapping from instrument uses to directed-motions. Observe that, unlike *process*, this coercion is not a subscene coercion. Observe also that, as stated, this coercion is alarmingly general. How might we constrain it?

What we require is a mapping from instrument uses to directed motions. The Sense Transfer Principle directs us to look in AR*. To define the meaning of impingement verbs like *hit*, we introduced the abstraction relation *impingement-directed-motion*:

$$\text{impingement-directed-motion}_{\sqsubseteq} : \textbf{impingement} \mapsto \textbf{directed-motion}$$

To define an impingement sense of *with* we introduced the abstraction relation *impingement-instrument-use*:

(89) $\text{impingement-instrument-use} : \textbf{impingement} \mapsto \textbf{instrument-use}$

This means the following relation is a member of AR*:

$$\text{impingement-directed-motion} \circ \text{impingement-instrument-use}^{-1}$$

This is a mapping from instrument uses to directed motions as required. Note it is defined for any instrument use related to an impingement and that impingement's directed motion. This mapping will suffice to license the *instrument-use-process* coercion whenever it is applied to an impingement directed motion and in the case of (90) it must be, because those are the only directed motions hit/2 is true of.

Suppose we then define:

$$\text{instrument-use-process} = \text{impingement-directed-motion} \circ \text{impingement-instrument-use}^{-1}$$

We may then define $\text{hit/3}_{\text{with}}$ using this coercion relation:

(90) $\text{hit/3}_{\text{with}} = \text{hit/2} \circ \text{instrument-use-process} \circ \mathit{process}$

The *process*-role belongs to simple actions, so (90) says that $\text{hit/3}_{\text{with}}$ is a predicate true of a simple action whose process is an instrument use which can be coerced to a directed-motion which hit/2 is true of. This sense is shown in attribute-value style in (91):

(91)
$$\begin{bmatrix} \textit{simple-action} & \\ \text{rel} & \text{hit/3} \\ \text{actor} & \boxed{1} \\ \text{theme} & \boxed{2} \\ \text{process} & \begin{bmatrix} \textit{process} & \\ \text{instr} & \boxed{3} \\ \text{underg} & \boxed{2} \end{bmatrix} \xrightarrow{\substack{\text{instrument-}\\ \text{use-}\\ \text{process}}} \begin{bmatrix} \textit{directed-motion} & \\ \text{rel} & \text{hit/2} \\ \text{theme} & \boxed{3} \\ \text{goal} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

The intuition of using AR*to constrain coercion relations can be stated a little more clearly in light of this example. The coercion licensing an instrumental valence of *hit* was licensed because we had two abstraction relations connecting directed motions and instrument uses to a single point in the domain of circumstances, impingements. That in turn happened because we had participant projections from impingements to directed motions for the impingement verbs, using *impingement-directed-motion*:

$$\text{impingement-directed-motion}_{\sqsubseteq} : \textbf{impingement} \mapsto \textbf{directed-motion}$$

Furthermore to define, an impingement sense of *with* we introduced the abstraction relation *impingement-instrument-use*:

(92) $\text{impingement-instrument-use} : \textbf{impingement} \mapsto \textbf{instrument-use}$

This means the following relation is a member of AR*:

$$\text{impingement-directed-motion} \circ \text{impingement-instrument-use}^{-1}$$

Thus, the coercion from a directed motion to an instrument use is licensed precisely because there was an oblique marker available in the target valence to mark the right impingement participants. (Figure 2 summarizes the participant projections from impingements.)

The key point is that the coercion from instrument uses to impingement is highly restricted. The sortal restrictions on

$$\text{impingement-directed-motion} \circ \text{impingement-instrument-use}^{-1}$$

$$
\begin{tikzcd}
\textbf{directed-motion}\,[\text{hit}] & \\
\textbf{impingement} \arrow[u, "\text{impingement-directed-motion}"'] \arrow[d, "\text{impingement-location}"'] & \textbf{instrument-use}\,[\text{with}] \arrow[l, "\text{impingement-instrument-use}"] \\
\textbf{location}\,[\text{against}] &
\end{tikzcd}
$$

Figure 2. Impingement Participant Projections

are

$$\textbf{instrument-use}_{\text{impingement}} \mapsto \textbf{directed-motion}_{\text{impingement}}$$

where

$$\textbf{instrument-use}_{\text{impingement}} = \text{Domain-sort}(\text{impingement-instrument-use}^{-1})$$

That is, only impingement related instrument uses are in the domain and only impingement related instrument uses are in the range. The coercion is thus **circumstance-preserving**. We examine some non-circumstance preserving coercions in the next section[33]

Note that the sense defined in (90) constrains only the *process* role, defined for both the *simple-action* and *resultant-action* frames. The sense of *hit* defined in (90), then, is also compatible with the following argument structure.

[33] Observe that the *instrument-use-directed-motion* coercion does in fact need constraining. Consider the following verbs:

(93) a. John swung the bat at Mary.
b. * John swung Mary with the bat.

Now *swing* appears to be a directed motion verb, (93a) appears to be a causal version of it, which ought to be realized by the *directed-action* argument frame, but the coercion that licenses an instrument valence is unavailable. If this was an accidental gap in the pattern of the valence alternation, unrelated to the semantics of *swing*, this gap could be handled by the evaluation measure, as discussed in Section 10. But in fact as noted by a number of authors, the alternation between the valence (86b) and (86c) is limited to impingement verbs.

(94)
$$\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{resultant-action}} \\
\text{rel} & \text{hit/3} \\
\text{actor} & \boxed{1} \\
\text{theme} & \boxed{2} \\
\text{process} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{process}} \\ \text{instr} & \boxed{3} \\ \text{underg} & \boxed{2} \end{array}\right] \xrightarrow{\text{instrument-use-process}} \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{directed-motion}} \\ \text{rel} & \text{hit/2} \\ \text{theme} & \boxed{3} \\ \text{goal} & \boxed{2} \end{array}\right] \\
\text{result} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{telic-process}} \\ \text{p-theme} & \boxed{2} \end{array}\right]
\end{array}\right]$$

Assuming that locations can be coerced into the *result* role, the same sense, then, can account for the valence in (86d).

This predicts that instrumentals and resultant locations ought to be able to co-occur. And it appears they can:

(95) Hank Aaron hit the ball into the gap with a 32-ounce bat.

An analogous account will carry over to *break*. Let us call the senses in (86f-h) $\text{break}/2_{\text{against}}$, $\text{break}/3_{\text{with}}$, and $\text{break}/3_{\text{against}}$, respectively. As in Section 4.4, we continue to call the valence in (86e) break/1. Then we can define all four senses with one coercion:

$$\begin{aligned}
\text{break}/2_{\text{against}} &= \text{break}/3_{\text{against}} \\
&= \text{break}/2_{\text{with}} \\
&= \text{break}/1 \circ \textit{result}
\end{aligned}$$

In attribute-value notation, that coercion is either:

$$(96)\quad \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{resultant-action}} \\ \text{rel} & \text{break/2} \\ \text{actor} & \boxed{1} \\ \text{theme} & \boxed{2} \\ \text{process} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{process}} \\ \text{p-theme} & \boxed{2} \end{array}\right] \\ \text{result} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{telic-process}} \\ \text{rel} & \text{break/1} \\ \text{p-theme} & \boxed{2} \end{array}\right] \end{array}\right]$$

or

$$(97)\quad \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{change}} \\ \text{rel} & \text{break/2} \\ \text{theme} & \boxed{2} \\ \text{process} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{process}} \\ \text{p-theme} & \boxed{2} \end{array}\right] \\ \text{result} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{telic-process}} \\ \text{rel} & \text{break/1} \\ \text{p-theme} & \boxed{2} \end{array}\right] \end{array}\right]$$

The reason one relation suffices for all four valences is that the verbal circumstances constrain the *result* role and the obliques in question all constrain the *process* role. Thus there is no sortal incompatibility between the instrumental and the head. In the case of hit/3_{against}, on the other hand, both the instrumental eventuality and the hitting eventuality needed to occupy the *process* role, and that was impossible without a coercion relation.

This solution, however, raises several questions. The consequence of assuming that *break* has one-participant circumstances is that neither of the oblique participants in (98a) and (98b) can be a core circumstantial participant.

(98) a. John broke the vase with the hammer.
b. John broke the hammer against the vase.

The question then is: Where do they come from? Is the *process* role of *break/2* completely unconstrained? The answer, of course, is that it is not:

(99) He broke the hammer to the wall.

We attempt to answer these questions in the next section, defending and extending the account.

6.2. Circumstantial Constraints and Argument Structure

In this section we extend the account of verbs of hitting and breaking in Section 6.1, introducing the concept of coercion relations between circumstances. This means that certain kinds of circumstances are linked to others in AR*, allowing for the formation of complex predications.

Two linked questions arose in the account of verbs of breaking:

1. What constrains the *process* role for *break/2*?
2. What participants do the oblique participants of *break/2* correspond to, given that they are not in the core circumstances of *break/1*?

According to the analysis presented in the last section, the case of $\mathrm{hit}/3_{\mathrm{against}}$ and $\mathrm{hit}/3_{\mathrm{with}}$ is somewhat different from the case of break/2. The *hit* predicates were defined in terms of constraints on the process role of a simple action, and the prepositions *against* and *with* were predicated of the eventuality filling that process role. On that account, the verb meaning required that the process role be filled with the right sort of directed motion. But in the case of break/3 the verbal head constrains the *result* role. Thus far, nothing we have said constrains the process role of a resultative action whose result is a breaking. That seems to overgenerate the possibilities for obliques, as shown by example (99).

We will argue that the required constraint is circumstantial in nature. The question is: what kind of circumstances can cause breaking? A natural answer, consistent with common sense physics, is impingement. Similarly, when we turn to other simple action verbs like *throw*, we want an impingement to be a natural result of *throwing*:

(100) He threw the ball against the wall.

But we do not want an impingement to be able to *cause* a throwing the way it can cause a breaking. It is not that one cannot imagine some Rube Goldberg situation in which an impingement of some kind causes an actor to launch a projectile. It is simply that such a situation is not canonical.

Again the facts seem circumstantial: *throw* naturally describes circumstances in which the result is projectile motion, and the cause is a launching action by an agent. The former is consistent with impingement and the latter is not.

What is missing is a general account of which kinds of circumstances can play causal roles in others. That is, we need, not a physicist's account, but an account of what causality is conventionalized in the language.

We propose to model that with mappings between circumstances, here, impingement and shape change circumstances:

(101) $$\begin{bmatrix} \textit{impingement} & \\ \text{impinger} & \boxed{1} \\ \text{impingee} & \boxed{2} \end{bmatrix} \overset{\text{causes}_1}{\mapsto} \left(\begin{bmatrix} \textit{state-change} & \\ \text{sc-theme} & \boxed{1} \\ \text{end-state} & \begin{bmatrix} \textit{shape-loss} & \\ \text{state-bearer} & \boxed{1} \end{bmatrix} \end{bmatrix} \right)$$

Note that the arrow here does not stand for entailment. Not every impingement causes a shape-loss, and not every shape-loss is caused by an impingement. The arrow captures a conventionalized causal connection between impingement and shape change. Thus we have simply posited a partial mapping.

The need for a partial mapping can be shown even for the limited case of impingements and shape losses. There are two ways an impingement can cause a shape loss; either the impingee changes shape or the impinger does. These correspond to breaking the vase with a hammer and breaking the hammer against the vase, respectively. Thus there is an alternative conventional causal relation:

(102) $$\begin{bmatrix} \textit{impingement} & \\ \text{impinger} & \boxed{1} \\ & \\ \text{impingee} & \boxed{2} \end{bmatrix} \overset{\text{causes}_2}{\mapsto} \left(\begin{bmatrix} \textit{state-change} & \\ \text{sc-theme} & \boxed{2} \\ & \\ \text{end-state} & \begin{bmatrix} \textit{shape-loss} & \\ \text{state-bearer} & \boxed{2} \end{bmatrix} \end{bmatrix} \right)$$

Given a set of such constraints we can provide a "semantics" for the *process-result* relation between impingement directed motions (**directed-motion$_{\textbf{impingement}}$**) and shape changes:

(103) $\text{causes}_i \circ \text{impingement-directed-motion}^{-1} \circ \text{process} :== \text{shape-loss-state}^{-1} \circ \text{result}$

The constraint in (103) sets up the following composable mappings between the argument structures and the circumstances:

$$\begin{tikzcd}
\textbf{change} \arrow[r, "\text{process}"] \arrow[d, "\text{result}"'] & \textbf{directed-motion} \\
\textbf{state} \arrow[d, "\text{shape-loss-state}"'] & \\
\textbf{shape-change} & \textbf{impingement} \arrow[l, "\text{causes}_1"] \arrow[uu, "\text{impingement-directed-motion}"']
\end{tikzcd}$$

What (103) guarantees is that an impingement i causes a shape change sc if and only if there is some change c such that the directed motion dm related to i is the process of c and sc is the result of c. The diagram shows the required relationships of all the relevant mappings. Starting at c the change, we can follow the *process* link to a directed motion dm and invert the impingement-directed-motion link to get to an impingement i.

How stipulative is such an account? Suppose we assume that there is a class of constraints that govern causal relations, relating conventionalized causes to the *process* and *result*s in changes. For each of a set of cause relations causes_i such that:

$$\mathbf{c}_1 \overset{\text{causes}_i}{\mapsto} \mathbf{c}_2$$

we want a corresponding role equation of the form

$$\text{causes}_i \circ \alpha^{-1} \circ \text{process} = \beta^{-1} \circ \text{result}$$

where $\alpha, \beta \in \mathrm{AR}$:

$$\begin{array}{l} \alpha : \mathbf{c}_1 \mapsto \mathbf{process} \\ \beta : \mathbf{c}_2 \mapsto \mathbf{process} \\ \mathrm{process} : \mathbf{process} \mapsto \mathbf{c}_1 \\ \mathrm{result} : \mathbf{process} \mapsto \mathbf{c}_2 \end{array}$$

That is, we want the abstraction relations to be a homomorphism preserving circumstantial causality relations in the argument structure *resultant-action* (or *change*). We call the homomorphic role equation a **conventionalized causal constraint**. The claim is the semantics of this argument structure should be constrained to accept only such conventionalized causal relations.

The same kind of conventionalized causal connection may be assumed between throwing and hitting a target, between hitting something and causing it to move, between freezing something and having it turn solid, and so on. Each conventionalized cause is implemented as a convention in the language by appearing in a role equation with *process* and *result* roles. Returning to the case of *break/2* appearing as the result of a resultant action, we see that two arguments have been added to the core circumstances:

1. the actor role

2. the second participant of the impingement, which is either a theme (*with*) or a goal (*against*).

We can now answer the two questions we started with:

1. What constrains the *process* role for *break/2*? Circumstantial constraints require that the filler of the process role be a directed motion related to an impingement in one of two ways.

2. What participants do the oblique participants of *break/2* correspond to, given that they are not in the core circumstances of *break/1*? The actor is introduced by a general relation in argument structure and belongs to no particular set of circumstances. The goal/theme belongs to a set of secondary circumstances which may be thought as a secondary predication within the argument structure. The circumstances of the two predications have been knitted together by circumstantial constraints.

The form of the account, then, is to augment circumstances with a set of conventionalized *relations between circumstances*, such as *cause*. These relations are intended to be part of the lexicon, but they are independent of any particular verb. Indeed, they are independent of the particular causation construction using *against* which we have investigated with *break*. In principle a single verb sense might be subject to any number of such causal constraints. Note also that however many causal constraints we have, we may still make do with one verb sense.

In effect the conventionalized causal links provide a form of extended circumstances, enabling us to link complex circumstances together and map them into a single argument frame.

Consider an alternative account of the facts of *break/2*. We might have a complex circumstance frame inheriting from impingement and shape change, giving us verbs that combine the concept of shape change and impingement. There would have to be two variants, one in which the impinger was identified with the state change theme, one in which the impingee is. This complex circumstance would then have to directly be realized by a complex argument frame like *change*, with no sense transfer. There is no objection to the form of this account. We need to admit complex circumstances with complex argument frames in any case. Consider *throw*, which has minimally an actor, a projectile, and a resulting motion path. There is no simpler subscene of throwing which leave out the actor or the path. Throwing is basically a 3-participant concept. Consider also the case of verbs of rebounding (*ricochet*, *rebound*, *carom*). These verbs must involve a complex scene in which there is first an impingement and then a resulting motion with a path.

Thus the chief objection to an impingement-shape-change circumstance is not formal. The chief objection is that a circumstance frame ought to be justified by a set of lexical items and there are no verbs which are specialized to be impingement-state change verbs. That is, all the verbs we are discussing enter into the frame:

(104) The hammer VERBed.

requiring core shape change circumstances with one participant. Even more telling, there are no verbs which decide the issue of whether the impinger or impingee is deformed.[34] We suggest that

[34] A contender is the verb *flatten*:

this very indeterminacy is diagnostic of a connection governed by underdetermined circumstance to circumstance relations.

Another example of a causal link relation between circumstances is the relationship between the two kinds of circumstances described in the following example of Goldberg's (1995).

(105) a. John sneezed the pepper off the table.
b. John sneezed.

An element of conventionalized causality enters in. Kay (**?**) points out the following:

(106) # John coughed the pepper off the table.

As far as creating streams of air, the physics of coughing and sneezing are close. Thus, what seems to be licensing the use of *sneeze* in what Goldberg calls the caused motion construction is that there some kind of conventionalized relation between sneezing and causing small (especially powdery) objects to move. Similarly, the following contrasts indicates that a degree of conventionalization (what Kay calls a "coinage") controls the use of the caused motion construction:

(107) a. His teammates laughed John out of the room.
b. His teammates laughed John into the bank.
c. # His teammates criticized John out of the room.

We may describe these facts by positing sneezing circumstances related to moving circumstances by a causal link.

(108) $$\begin{bmatrix} \textit{sneezing} & \\ \text{sneezer} & \boxed{1} \\ & \end{bmatrix} \overset{\text{sneeze-causes}}{\mapsto} \left(\begin{bmatrix} \textit{movement} & \\ \text{mover} & \boxed{2} \\ & \\ \text{destination} & \boxed{3} \end{bmatrix} \right)$$

Here there are no role identifications between the two events. We now add the conventionalized causal constraints that license (105a):

(i) ? The dough ball flattened.
(ii) ? The dough ball flattened against the board.
(iii) The rolling pin flattened the dough ball.

The question-marked sentences, though marked, seem not to be out. If they are out, we have a counterexample. In particular, *flatten* would be a shape change impingement verb which required the impinger to move.

(109) sneeze-causes $\circ$ sneezing-process$-1 \circ$ process $=$
motion-directed-motion^{-1}result

where we use sneezing-process as a standin for the abstraction relation for sneezing and motion-directed-motion is the abstraction relation for simple motion events.[35] Along with this, we now license the following sense transfer for *sneeze*:

$$\text{sneeze}/3 = \text{sneeze}/1 \circ \text{process}$$

This is entirely parallel to our definition of break/2 in terms of break/1, just as the conventionalized causal constraint in (103) is parallel to the causal constraint in (109). There are two differences: role equality has been asserted in (109), and role congruence was asserted in (103); and the domain of the cause relation in is much narrower in (109) than in (103). The use of role equality captures the following fact:

(110) a. * John sneezed the pepper.
b. John broke the hammer.

Use of *sneeze* as a process requires that the result be specified; use of *break* as a process does not.

But the more salient difference between our account of causal relations with *sneeze* is the specificity of the causal relation. There is a general highly productive relation between shape change predicates and impingement underlying their use in causal constructions. But the conventional causal relation between sneezing and cause is highly restricted. We return to this point in our comparison of our approach to that of Goldberg in Section 9.

Causal links are the second example of a significant relation between circumstance frames that we have seen. The first example was subscene relations like the *money-transfer* and *goods-transfer* relation between commercial events and possession transfers. A third example might be the scrutiny and seeking frames discussed in Section 3.3. We may think of the preposition *for* as having a desired object meaning that marks the desired object with verbs like *look for* and *search for*. This sense of *for* would have a participant

[35] We assume that *motion* is the circumstance frame *self-motion*, introduced in Section 3, directly inherits from.

projection like this:

$$\begin{bmatrix} \textit{seeking} & \\ \text{seeker} & \boxed{1} \\ & \\ \text{desired-object} & \boxed{2} \\ & \end{bmatrix} \xrightarrow{\text{seeking-ag-go}} \begin{bmatrix} \textit{purpose-sit} & \\ \text{actor} & \boxed{1} \\ & \\ \text{goal} & \boxed{2} \end{bmatrix}$$

The ransacking frame then would be related to seeking by a subscene relation as commercial events are to goods transfers:

$$\begin{bmatrix} \textit{ransack} & \\ \text{ransacker} & \boxed{1} \\ & \\ \text{search-goal} & \boxed{2} \\ & \\ \text{search-location} & \boxed{3} \end{bmatrix} \xrightarrow{\text{seeking}_{\sqsubseteq}} \begin{bmatrix} \textit{seeking} & \\ \text{seeker} & \boxed{1} \\ & \\ \text{desired-object} & \boxed{2} \end{bmatrix}$$

We require an argument frame for *ransack*, which we will call *ag-loc-sit*, which can directly realize *ransacking*:

$$\begin{bmatrix} \textit{ransack} & \\ \text{ransacker} & \boxed{1} \\ & \\ \text{search-location} & \boxed{2} \\ & \\ \text{search-goal} & \boxed{3} \end{bmatrix} \xrightarrow{\text{ransack-sit}_{\sqsubseteq}} \begin{bmatrix} \textit{ag-loc-sit} & \\ \text{actor} & \boxed{1} \\ & \\ \text{location} & \boxed{2} \\ & \\ \text{situation} & \boxed{4} \\ & \end{bmatrix}$$

The search goal has been unprojected and the situation left unconstrained. We can relate the two using the *seeking* relation:

$$\text{seeking-ag-go}^{-1} \circ \text{situation} = \text{seeking} \circ \text{ransack-sit}^{-1}$$

That is, the situation is the argument frame of the ransacking's seeking.

In sum, circumstance to circumstance relations give us a means to describe those cases that appear to have complex circumstances without hypothesizing a set of heads specialized for those complex circumstances.

6.3. Complex Scenes

We started out with the assumption that circumstantial scenes would have no complex scene structure, allowing for the possibility that a single circumstance might be carved into subpieces in incompatible ways by different perspectivalizations. This left open an important question.

How is the relation of circumstances to argument frames that do have substructure to be described? The example of the impingement frame and hit/2 and hit/3 will serve to illustrate some of the options.

We have described hit/2 as an impingement viewed as a directed motion (using the impingement-directed-motion coercion),and a hit/3 eventuality as a hit/2 eventuality coerced into simple-action (using the process coercion). But there is as yet no direct relation connecting impingements and simple-actions.

The first question is: Is one needed? It could be the case that we have said all that needs to be said about the relation of simple actions and impingements. In other words, it could be the case that simple action impingements are impingements to which an actor happens to stand in the usual instigating agentive relation, that composing the process role with hit/2 exactly captures the truth conditions of hit/3. In that case, we would be done. The relation of scene (simple action) to subscene (hit/2) would be perfectly described by the process role.

However, this appears not to be the case. Consider examples (86b) and (86c) again. Example (86c) may be used to describe a situation in which the stick is thrown; example (86b) may not. It appears to be the case that (86b) requires the actor to hold on to the stick throughout the hitting event, but (86c) does not. Moreover, this does not appear to be a special fact about *hit*, or even about impingement verbs. The same entailment contrast holds for (86d) and (86e). The valence with *against* requires manipulation by the agent throughout the impingement act. We call this the *manipulation entailment.*

We could account for this by positing special purpose argument structure frames that carried the entailment but this seems unsatisfactory. It is not clear that anything about this entailment extends beyond the range of impingement events and, if so, any argument structure frame carrying the manipulation entailment would be an encoding of facts about impingements, contrary to the spirit of separating facts about circumstances from facts about argument frames.

A better solution would be to build the entailment into the original impingement frame and then define the mappings to argument structure to carry it.

Here is a way to do that. We first add a new participant to impingement:

$$\textit{manipulator} : \textbf{impingement} \mapsto (\textbf{animate})$$

The manipulator is an animate agent who manipulates the impingee throughout the impingement. Note that the manipulator role is optional. Not all impingements have a manipulator, as the case of the thrown stick, which may be described by (86c), shows. We now clearly have the problem of defining some relation between impingements and simple-actions, because we need to identify the manipulator with the actor, at least in those cases described with *against*.

The following role axioms do this:

(111) (a) $\textit{manipulator} = \textit{actor} \circ \textit{impingement-simple-action}$
(b) $\text{impingement-directed-motion}^{-1} \circ \textit{process} = \text{impingement-simple-action}^{-1}$

Axiom (b) says that all processes in the range of the impingement-directed-motion mapping must be the process of simple actions in the range of impingement-simple-action mapping.

Note that this is completely consistent with defining hit/3, as we did in the previous section, as:

(112) $[\![\text{hit/3}]\!] = \text{hit/2} \circ \text{process}$

Neither statement predicts the other. Axiom (111a) identifies the actor role with the manipulator role in the impingement scene and, in combination with (111b), brings it into certain entailment relations with the other roles of a simple action. Definition (112) is an instance of a general sense transfer pattern that exploits that mapping constrained by (111), allowing the same pronunciation to have both a directed-motion and a simple-action sense.

In contrast, (86c) is unaffected by (111). Although $\text{hit/3}_{\text{with}}$ does invoke the simple-action frame, the filler of the process role is an instrument-use, a process not in the range of *impingement-directed-motion*. Therefore the actors of such simple-actions will not be identified with a manipulator, and the manipulator entailment will not go through.

The key features of this account seem to be the following:

1. Separating out the general features of the causative alternation with *hit* from those idiosyncratic to impingements required separating circumstances from argument frames.

2. Also required was the ability to make idiosyncratic statements about the circumstance to argument frame mapping, in particular, by making the mapping functions themselves first-class citizens that appeared in axioms. What (111) is is a statement that when impingements are realized as simple actions certain idiosyncratic relations hold with the directed motion part of the projection.

3. Circumstances may contain participants like actors, which are projected only as parts of complex scenes.

Consider another property of complex scenes as yet unaccounted for:

(113) a. * The fence struck with the stick.
b. The stick struck (against) the fence.
c. * The vase broke with the hammer.
d. The hammer broke against the vase.

Instrumentals, in constrast to *against*-marked obliques, are not welcome in these two-participant valences. We could account for these restrictions by placing sortal constraints independently on the *change* and *simple-action* frames, precluding instrument uses from occupying the process role, but this would prevent *directed-action*, which does take instrumentals, from inheriting from either. In addition, it would leave unaccounted for the following example of Fillmore's (Fillmore, 1967)

(114) # The storm broke the window with a tree branch.

All of the anomalous sentences in (113) and 114) would be accounted for if we assumed that *with-* marked instruments needed to be in the control of an actor. This can be implemented by adding an obligatory controller role to instrument processes and requiring identity with an actor:

$$(115)\quad \begin{bmatrix} \textit{instrument-use} & \\ \text{rel} & [\,] \\ \text{controller} & \textbf{animate} \\ & \\ \text{instrument} & \textbf{entity} \\ & \\ \text{undergoer} & \textbf{entity} \end{bmatrix}$$
$$\textit{actor} :== \textit{controller} \circ \textit{process}$$

Having made the *controller* role obligatory, we have guaranteed that it must be linked in argument structure, and the role ordering in (115) provides a way of doing that. Valences that have no actor will have no way of exploiting that link, so the anomalous examples in (113) and (114) will be out. Observe that, like the causality constraints discussed in the last section, these are auxiliary constraints independent of particular lexical entries. There is an important, difference, however, in that this constraint makes no mention of an abstraction relation or of circumstances. It is stated entirely in terms of argument structure relations.[36]

Moreover, it is crucial that the circumstances be exempted from filling the *controller* role by argument projection. Note that impingement verbs must *not* identify the manipulator with the controller (it must be a non-participant argument), because if they did, all impingement instruments would have to be manipulated, and as (86c) shows, that is wrong. Thus, it is important that the facts in (113) and (114) be accounted for at the level of argument structure and not at the level of circumstances.

[36] A potential problem for this account is raised by examples like:

(i) The door opens with a key.

Here, apparently, is an instrument without a controller agent. There are two possible accounts of these cases that might legitimately render them irrelevant. First, (i) may be a species of middle, that is, a sense derived from a sense for which the actor role is defined; second, this may be a different sense of *with* for which the control entailment does not hold, as suggested by:

The switch opened the door with a small electromagnet.

7. Other simple participant projections

In this section we deal with the occurrence of *for*-phrases with verbs like *sell*, *buy* and *spend*, and *pay*. Summarizing the relevant facts:

(116) a. John spent \$300 for the sweater.
b. John paid \$300 for the sweater.
c. John bought the sweater for \$300.
d. Mary sold the sweater for \$300.

The sentences in (116) might be true descriptions of a single commercial event. A key point is the preposition *for*- seems to bear a single meaning in all four examples, a meaning having to do with exchange. In (a) and (b), based on the money transfer, the *for*-phrase selects the goods; in (c) and (d), based on the goods transfer, it selects the money.

In the treatment of commercial event verbs outlined in Section 4.1, *for*-phrases were not included in the argument projections. In this section, we defend this move, identify an important class of adjuncts, *circumstantial adjuncts*, to which *for*-phrases belong, and present an account of *for*-phrase modifiers.

The key property distinguishing *for*-phrases from other commercial event modifiers is the following: With a variety of verbs of possession transfer, a *for*-phrase adds the entailment that there is an exchange, that the possession transfer associated with the main verb is linked with another reciprocal transfer:

(117) a. John exchanged the jackknife for a lighter.
b. John traded the jackknife for a lighter.
c. John gave Mary the sweater for \$300.
d. Mary acquired the sweater for \$300.
e. John gave Mary the jackknife for a lighter.

In (117a) and (117b) the same of meaning of *for* seems to arise marking the same exchanged-item participant with the verbs *exchange* and *trade*, which are specifically limited to exchange situations. In (117c-e), the *exchange-for* meaning, as we will call it, arises with generic verbs of possession transfer. Thus, the facts about *exchange-for* are not facts about commercial event verbs, or even exchange verbs, but about verbs of possession transfer in general.

Note, that what is going on is specific to *for* and an entailed exchange. For example, *from*-phrases do not have the property of being able to import another possession transfer when modifying a donation verb:

(118) a. # John gave the book to Mary from Sue.
b. John infected Mary from Sue.

Example (118a) cannot mean John gave the book he got from Sue to Mary, or John gave to book to Mary in exchange for something from Sue. Example (118b) cannot mean John gave Mary the infection he got from Sue.

Summing up: what distinguishes *for*-phrases from other obliques with commercial event verbs is that they seem to be able to import their own distinct circumstance frame, a frame involving circumstances of exchange. Assuming that we treat *buy* and *sell* as acquisition and donation verbs, respectively, any account of how *exchange-for* works with verbs like *get* and *give* ought to carry over automatically to *buy* and *sell*. Putting this in terms of our current argument structures, it's an independent property of the acquisition and donation frames that *for*-phrases can coerce them into exchanges. Since *buy* and *sell* are perspectivalized as acquisitions and donations, that account ought to simply be inherited.

We begin with the circumstantial account of *exchange*. We will proceed by way of an account of those possession transfers which are in a reciprocal relation with other possession transfers. We will call those eventualities exchange possession transfers, assuming the following relationship:

(119) **exchange-pt** $\sqsubset$ **possession-transfer**

$$\begin{bmatrix} \textit{exchange-pt} & \\ \text{donor} & \boxed{1} \\ \text{recipient} & \boxed{2} \\ \text{possession} & \boxed{3} \end{bmatrix} \xrightarrow{\text{recip-pt}} \left\{ \begin{bmatrix} \textit{exchange-pt} & \\ \text{donor} & \boxed{2} \\ \text{recipient} & \boxed{1} \\ \text{possession} & \boxed{4} \end{bmatrix} \right\}$$

We declare an exchange-pt sort as a subsort of possession transfer. Recip-pt is a total relation on exchange-pts defined so that possession transfers that stand in the relation are reciprocal. The axioms that more precisely state what we want follow:

$$\begin{array}{l} \text{recip-pt} : \textbf{exchange-pt} \longleftrightarrow \textbf{exchange-pt} \\ \mathit{donor} = \mathit{recipient} \circ \text{recip-pt} \\ \mathit{recip} = \mathit{donor} \circ \text{recip-pt} \\ \text{recip-pt} = \text{recip-pt}^{-1} \end{array}$$

The first axiom makes recip-pt a one-to-one relation on exchange possession transfers. The next two spell out the role mappings indicated in (119). The last axiom simply makes recip-pt symmetric.

We assume an argument frame for various senses of *for* involving desired objects.

$$\begin{bmatrix} \mathit{purpose\text{-}sit} & \\ \text{event} & \boxed{1} \\ & \\ \text{desired-object} & \boxed{2} \end{bmatrix}$$

We assume that, relative to different circumstances, this frame serves for examples like the following:

(120) a. John danced for a small fee.
b. John gave Fred a first round bye for a small fee.

These examples differ somewhat from the *exchange-for* cases other verbs. In these cases it is the **action** and not some participant in it that is interpreted as being in exchange for the compensation: In (120a) John's (unexpressed) audience gives a dollar but it is the entire dancing action that the audience "receives" in return. The same reading can be observed in (120b) in the circumstances where some unexpressed third agent gives John the fee. We call this sense of *for* the *action-exchange-for*. Although closely related to *exchange-for*, it requires a different circumstances, as well as being quite free in its sortal restrictions. However we assume both senses of *for* use *purpose-sit* as their argument structure.

We now show the argument projection axioms relating reciprocal possession transfers to purpose situations.

$$\begin{array}{l} \text{exchange-pt-purpose-sit(xpt-ps)} : \textbf{exchange-pt} \mapsto \textbf{purpose-sit} \\ \quad \text{(a)}\ \ \mathit{desired\text{-}object} \circ \text{xpt-ps} = \mathit{possession} \circ \text{recip-pt} \\ \quad \text{(b)}\ \ \mathit{event} \circ \text{xpt-ps} = \mathit{circ}^{-1} \circ \text{recip-pt} \end{array}$$

Role projection (a) says the desired object of a possession transfer's purpose situation is the same as the possession in its reciprocal transfer. Role projection (b) says the event object of a possession transfer's purpose situation is the same as whatever argument structure its reciprocal transfer is realized as.[37]

Given this structure for exchanges and their argument projections, the meaning of *exchange-for* is routine:

(121) $\text{xch-for} = \lambda x,\ e[\text{xpt-ps}^{\upharpoonleft}(e) \wedge \textit{desired-object}(e) = x\,]$

Grammatically, we assume purpose situations are external modifiers like the *location* role. Somewhere at a fairly abstract level in the hierarchy of argument structures, purpose-situations are introduced as a role, perhaps along with actors:

$$\begin{bmatrix} \textit{action} & \\ \text{self} & \boxed{0} \\ \text{actor} & \boxed{1} \\ \text{purpose-sit} & \begin{bmatrix} \textit{purpose-sit} & \\ \text{event} & \boxed{0} \\ \text{desired-object} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

For-phrase modifiers need to modify purpose situations and will be coerced into the *purpose-sit* role in the usual manner.

It remains to be shown how commercial events are related to this account of exchange. In Section 4.1, we showed how commercial events need to be related to distinct possession transfers, a goods transfer and a money transfer. What we now need to say is that these are reciprocal. The following axiom does this:

(122) $\text{recip-pt} \circ \text{goods-transfer} = \text{money-transfer}$

Several things follow from Axiom 122. Having made the goods transfer and the money transfer reciprocal we can now deduce some of the role mappings associated with the money transfer

[37] Critically Circ^{-1} is not a function but a relation. For example, commercial events have but one goods transfer, by assumption. Thus a single goods transfer must be related by Circ^{-1} to an acquisition (for *buy*), a donation (for *sell*) and a resource consumption (for *spend*).

from facts about exchange. Thus, once we say:

$$\begin{aligned}
&buyer = recipient \circ \text{goods-transfer} \\
&seller = donor \circ \text{goods-transfer} \\
&goods = possession \circ \text{goods-transfer}
\end{aligned}$$

all we need to say about money-transfer is that the money is what is transferred:

$$money = possession \circ \text{money-transfer}$$

The donor and recipient of the money-transfer are deducible from the fact that the money reciprocates the goods transfer: Given the symmetry and one-to-oneness of recip-pt, the following also follows from (122):

(123) $\text{recip-pt} \circ \text{money-transfer} = \text{goods-transfer}$

In sum, we can ascribe some of the structure of commercial events to the fact that they involve exchange.

Given Axiom (122) guaranteeing the reciprocality of money transfer and goods transfer, and the treatment of exchange above, an *exchange-for*-phrase modifying *buy* and *sell* must mark the money. The following diagram summarizes the assumed relations for the case of an acquisition verb like *buy*:

$$\begin{array}{ccc}
\textbf{exchange-pt} & \xrightarrow{\text{xpt-ps}} & \textbf{purpose-sit} \\
{\scriptstyle\text{recip-pt}}\Big\downarrow & & \Big\downarrow{\scriptstyle\text{event}} \\
\textbf{exchange-pt} & \xleftarrow[\text{circ}]{} & \textbf{acquisition}
\end{array}$$

As defined *exchange-for* requires some eventuality whose circumstance are an exchange transfer. This of course is true of *spend* and *pay* as well as *buy* and *sell*. The only difference is that the definitions of *spend* and *pay* builds in the money transfer instead of the goods transfer, so the reciprocal possession marked in the *for*-phrase will be the goods.

A key feature of this account is that the *event* role of the *for*-phrase modifier has only a very general sortal constraint in terms of argument structure. What constrains it is the role equation:

$$event \circ \text{xpt-ps} = circ^{-1} \circ \text{recip-pt}$$

This axiom constrains the event object of a purpose situation to be those that are the argument projections of reciprocal possession transfers. This is a simple concept to state at the level of circumstances, and a fairly mixed bag at the level of argument structure.

For example, *exchange-for* modifies *buy*, *sell*, *pay*, and *spend* despite their varied argument structures. The case of *spend* stands out in particular. Acquisition and donation, the argument structures, for *pay*, *buy*, and *sell* are both defined in terms of possession transfer. But resource consumption, the argument structure for *spend*, is not. Thus capturing the class is most naturally accomplished at the level of circumstances.

It is worth recalling, as noted in Section 4.1, that there are phenomena motivating a distinction between *spend* and the other verbs at the level of argument structure. For one thing the seller is unrealizable, an odd fact if the verb is defined along with the others, as describing a possession transfer eventuality. For another, it behaves differently with respect to productive sense transfers. In particular, the dative valence is possible with *buy*, *sell*, *pay*, but not *spend*:

(124) a. # John spent Mary $300 for the sweater.
b. His parents bought John the sweater for $300.
c. John bought Mary the sweater for $300.
d. John paid Mary $300 for the sweater.

This is not the place to address the difficult subject of dative constructions.[38] But it is worth pointing out here that the account of dative constructions will require a sense transfer making reference to the argument structure facts that distinguish *spend* from *buy*. This suggests that the assumptions made so far in this work are pointing in the right direction. Sense transfers are stated on argument structures and are basically constrained by them, while external modifiers such as *exchange-for* are constrained by circumstances through the use of the *circ* role.

[38] Note, for example, that the role John fills in *his parents bought John the sweater for $300* is not one provided for in our commercial event scene thus far. He is not the buyer, because he does not supply the money. He is the *new possessor*. Thus a new and more complex kind of circumstance is being created.

We conclude with discussion of two points, first, the treatment of *exchange-for* as an external adjunct, second, a defense of the general notion of circumstantial modifier.

We have treated a class of *for*-phrases (purpose-sit modifiers) as external adjuncts. At the same time we have shown how one sense of *for*, *exchange-for*, can still mark a circumstantial participant This analysis thus makes the claim that core participants of a head's circumstances may sometimes be realized as adjuncts. [discussion]

Another aspect of our treatment of *for* is that it made critical use of the *circ* role. The essential intuition of this move is that there is a class of modifiers for which the sortal constraints are best started at the level of circumstances. [discussion]

8. Evaluation, Mismatch and Polysemy

We adopted a theory which at the outset was declared to admit a large open class of concepts, with the hope that this would give us a better chance of doing cross-linguistic comparsion and of understanding systematically the ways in which a large class of meanings is realized by a small set of valences.

One consequence of the approach we have taken is a proliferation of senses. Verbs and prepositions have circumstance specific senses and there are a lot of circumstances.

In this section, we sketch an approach to this problem based on some ideas in Bochner (1993), which is in turn based the full-entry lexicon theory of Jackendoff (1975). The primary goal of those works is to develop a theory of the lexicon that confronts the productivity and semi-productivity of morphological rules. Jackendoff's idea is that a lexicon is simply a list of all the forms together with a statement of the patterns (rules) they exhibit and an algorithm that measures the information content of the lexicon, "charging" only for independent (unpredictable) information. The more unpredicatble information that list of forms has, the more information it takes to specify it and the harder it is to learn. Bochner (1993) takes up this standard and develops a fairly worked out proposal for such an *evaluation measure*.

A key assumption that Bochner makes is that the cost assigned by the evaluation measure be sensitive to the productivity of a process. This leads immediately to two further innovations:

1. Once penalizing patterns for their lack of productivity is incorporated into the evaluation measure, it becomes profitable to state productive subcases of semiproductive general patterns. For example, +ity suffixation on adjectives is vastly more productive when +able is attached. Bochner posits a pattern direct relating forms like *movable* and *movability.* Even though both forms are predictable from more general processes affixing stems with +able and +ity (*vane, vanity*), the more general pattern of +ity suffixation is not productive. The subpattern combining both affixes is extremely productive.

2. Bochner also allows partial mismatches between rules and instances. This addresses cases like that of *retribution* and *conflagration*, discussed in Lakoff (1965) and Jackendoff (1975). There is a pattern in English relating

$$\begin{bmatrix} \textit{Verb} \\ \text{X} \end{bmatrix} \longleftrightarrow \begin{bmatrix} \textit{Noun} \\ \text{Xtion} \end{bmatrix}$$

   which licenses pairs like

tabulate	tabulation
radiate	radiation
direct	direction
decide	decision
attribute	attribution

   Words like *retribution* and *conflagration* match the "output" of the pattern in form and semantics but they lack a paired "input" word. There are no verbs * *retribute* and * *conflagrate.* Bochner's evaluation gives these verbs credit for having partly predicable information. Jackendoff's proposal does the same work, but assumes a stage in the evaluation at which forms like * *retribute* and * *conflagrate.* exist. Bochner just directly admits partial matching.

The observation we begin with here is that polysemy exhibits the basic properties that motivate Bochner's innovations.

1. Senses cluster together into subpatterns. We have locative senses of *on*, instrumental senses of *with*, and so on.

2. Distinct senses of a word share features and are partly predictable, but there is no "rule" which perfectly captures all of them. The best that can be hoped for is some pattern which minimizes the cost of all the mismatches.

These properties motivate prototype theories of meaning (**?**), and notions like Herskovitz's **ideal meaning** (1986). For example, after examining a variety of meanings of the preposition *on*, Herskovitz proposes an ideal meaning encoding the notions of support and surface contact. But there is no sense in which the various subtleties she examines are predictable from that meaning.

[H's examples]

In the context of Bochner's proposal, the following idea seems promising: Suppose we try to capture ideal meanings and prototypes as part of the "mismatch" component of the grammar. It is not really important that this mismatch component be part of the evaluation measure of a grammar. The key distinction is between the generative component, which admits all and only entities satisfying some set of constraints, and the mismatch (or markedness) component, which admits entities at a cost based on the degree of their divergence from established patterns. Bochner's work may be viewed in this context as one of a family of approaches (including various versions of Optimality Theory, and unification-base theories admitting default unification) as a concrete architecture for a mismatch component. The insight that productivity should be a key parameter in scoring mismatch is important, as is the idea that once productivity is admitted, subpattern identification needs to be a part of mismatch scoring.

Once mismatch is allowed, the theory of grammar really becomes quite different. The central methodological question becomes the identification of some reasonable "distance measure" by which degree of mismatches can be measured, and the central descriptive question becomes the identification of patterns that are centroids, points in a descriptive space around which there is a cluster of items. By way of illustration, the classic notion of linguistic generalization may be likened to the notion of generalization ("disjunction") used in unification frameworks. The generalization of A and B ($A \sqcap B$) is the informational "greatest lower bound", the most specific thing which is more general than A and B. This definition in effect loses all the conflicting information between A and B. Generalization in one form or another is the goal in stating a set of efficient declarative constraints that admit all and only the objects of the grammar. On the other hand, if we are trying to minimize the cost of new information, we may arrive at very different answers than generalization does, tolerating a few mismatches in order to predict a larger amount of information. The following example illustrates:

(125)

$$\begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \\ \mathrm{Att}_2 & \mathrm{B} \\ \mathrm{Att}_3 & \mathrm{C} \end{bmatrix} \begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \\ \mathrm{Att}_2 & \mathrm{D} \\ \mathrm{Att}_3 & \mathrm{C} \end{bmatrix}$$

$$\begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \\ \mathrm{Att}_2 & \mathrm{C} \\ \mathrm{Att}_3 & \mathrm{D} \end{bmatrix} \begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \\ \mathrm{Att}_2 & \mathrm{C} \\ \mathrm{Att}_3 & \mathrm{D} \end{bmatrix}$$

$$\begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \end{bmatrix} \text{ total cost: 8}$$

$$\begin{bmatrix} \mathrm{Att}_1 & \mathrm{A} \\ \mathrm{Att}_1 & \mathrm{C} \\ \mathrm{Att}_1 & \mathrm{C} \end{bmatrix} \text{ total cost: 4}$$

(125a) shows 4 lexical entries and (b) and (c) show two different patterns that might be hypothesized by an EM trying to minimize the cost of this mini-lexicon; (125b) shows the classic greatest lower bound or "generalization", which simply represents all the nonconflicting information between the structures; the cost of the lexicon is simply 1 unit per unpredicted value per attribute per lexical entry. Since there are 4 lexical entries with two unpredicted attributes each, the cost is 8. The structure in (125c) has been chosen to try to minimize mismatch. The strategy used was: for each attribute, choose the value held by the greatest number of lexical entries. The result is a structure that not only isn't a lexical entry; it isn't even compatible with a lexical entry. Every piece of information in it conflicts with some lexical entry. Yet by our simple evaluation measure, it is much cheaper than the generalization in (125). This is a toy example not intended to be linguistically realistic, but it does illustrate the point of how much the game changes once mismatch is admitted. If the goal is to minimize mismatch, the problem of finding the best grammar is what is called a minimal descriptive length problem; it is closely related to the problem of finding an optimal encoding. The key point here is that if we concede that certain kinds of generalizations should be captured as simply as statements of the most economical pattern covering the cases, the nature of what we call a generalization will change.

[sketch of Bochner]

[ideal meaning for against]

9. Other approaches

9.1. Goldberg

The account here owes much in spirit and concept to the account of Goldberg (1995), particularly as concerns the account of valence alternations in Section 6. Goldberg studies a number of valence alternations such as the dative alternation and caused motion construction. The argument structures investigated here are very much like Goldberg's valence constructions, in that in both cases, they are agglomerations of valence-determining semantic information.

One difference between the two approaches may appear to be major, but is perhaps a separable issue: The argument structures proposed here are purely semantic objects. Goldberg's constructions are pairings of syntactic and semantic information. The approach adopted here is based on the assumption that valences are largely predictable from argument structures, and that therefore the linking theory should be a separate module of a lexical semantic theory. If Goldberg were to agree with this conclusion and factor the syntax out, then her constructions would use just the sort of semantic patterns endorsed here.

But there is a more significant difference between the two approaches. The mechanism used to account for valences is basically the same; the mechanism used to account for valence alternations is not. The assumption here is that the grammar includes a separate set of "sense transfer" relations, constrained, by and large, to very specific semantic neighborhoods. Thus the various senses of the impingement relations were connected by coercion relations such as *process*, *result*, and *instrument-use-directed-motion* restricted to mediated-actions, directed actions, and impinging instruments, respectively. If an argument structure is in the range of such a coercion relation, then it has the ability to "extend" itself to heads in the domain. Otherwise it only applies to a set of core meanings, namely those made eligible by the entailment principle. Thus, a key question in understanding whether a particular extended sense of a verb is possible is determining whether there is a productive sense transfer appropriate to licensing it.

In this connection I would like to follow Kay (**?**) in suggesting that the following example, discussed in Section 6.2, is not an example of a productive sense transfer:

(126) a. John sneezed the pepper off the table.
b. # John coughed the pepper off the table.

Kay argues that examples like (126a), from Goldberg (1995), are not instances of Goldberg's caused motion construction, but rather of what he calls a "coinage", a novel extension of an existing pattern to a new domain. He points out that conversion of intransitives to transitives via the caused motion construction is not productive, contrasting (126a) with (126b). He thus differs from Goldberg in how far he is willing to say the caused motion construction goes.

On the account presented in Section 6.2, (126a) is like other caused motions that it uses the same argument structure, but unlike them in what licenses that use. What licenses (126a) is a very narrowly defined conventional causal constraint relating sneezings to the motion of material.

I submit that it is useful to separate the argument structure part of the construction from the sense transfer part, and that when this separation is made, a variety of sources for the caused motion valence emerge. Consider, for example, (127):

(127) a. The wind blew the pepper off the table.
b. The pepper blew off the table.

The relation between (127a) and (127b) is simply that of an argument frame with an actor to one without an actor and arises because of a circumstance that optionally fills the actor role.

The loading alternation of (128) is a different case.

(128) a. John loaded the truck with hay.
b. John loaded hay onto the truck.

The relationship of (128a) to (128b) can be captured by a productive circumstance-preserving sense-transfer(Anderson, 1971), one which we have not analyzed, but which relates views of circumstances of material transfer as caused motions to a valence employing a material-applying sense of *with*.

Goldberg's example

(129)

John locked Mary out of the room.

John locked Mary into the cellar.

which she also assimilates to the caused motion valence, cannot be analyzed as caused motion under the assumptions made here, because there is no motion, but it can be analyzed using the same resultative action argument frame, in which the result of a locking process is Mary's location.[39]

What unites these examples is action which results in an object having a particular location. What separates them, on the account proposed here, is different degrees of productivity in the processes which license the resultative valence. Example (128) is due to a productive sense transfer. Examples (127) and (129) are due to ordinary particpant projection obeying the entailment principle. Example (126), on the other hand, is licensed by an unproductive, very narrowly constrained conventional causal constraint.

[39] In order to do this, we need to grant *into* a sense which does not impute motion, but simply location that is a result.

In sum, the data examined in this paper have not created a compelling case for a caused motion argument structure. This frame would be a special case of resultative actions in which the results are directed motions. We have, however, assumed the existence of a directed motion argument structure, so the assumption that there is a causative version which adds an actor and a process would not be unnatural. The important point to make here is that on the current approach, verbs associated with that argument structure can have it licensed in a variety of ways.

9.2. Pusteyovsky

9.3. Jackendoff

Much of what Jackendoff seeks to accomplish through to decomposition of meanings in LCS is to capture valence structure similarities between different verbs. Here, for example, is an approximation of the Lexical Conceptual Structure representation of *sell*:

$$
\begin{array}{l}
[_{\text{Event}}\ \text{CAUSE} \\
\qquad ([_{\text{Thing}}],\ [_{\text{Event}}\text{GO}_{\text{Poss}}\ ([_{\text{Thing}}\text{GOODS}], \\
\qquad\qquad\qquad\qquad [_{\text{Path}}\text{TOWARD}_{\text{Poss}}([_{\text{Thing}}])\,]\,)\,]\,)\,]
\end{array}
$$

The representation for *sell* shares a great deal of structure with the representation for *give* and it is this shared structure which is responsible for shared valence properties, such as marking the goal with *to*.

In the current framework, argument structures roughly correspond to LCSs; circumstance frames to referential material, some of which belongs in other cognitive modules on Jackendoff's view. The inventory of basic argument structure concepts explored here is quite compatible with the basic concepts of LCSs:

1. ag-th-go, ag-th-so: source and goal relations not restricted to a particular domain

2. location: spatial orientation relations providing relative spatial information abotu a figure and a ground

3. directed-motion: telic motion along a path path

4. resultant action and change: a process and a result, with and without an actor.

5. simple action: an actor causally involved in a (possibly non-telic) process

But on the present approach, circumstances play an important theoretical role.

Much of the simplicity of argument structure frame has been won at the expense of factoring work out to circusmtances. For example, impingement verbs are realized as simple actions, but the constraints on the preposition selection are acheived through a general feature of participant projection and the way predicates get their sense definitions. A preposition sense that is a projection from a particular circumstance frame is sortally restrited to mark eventualities circumstantially compatible with those circusmtances. Thus, an impingement preposition like *on* marks only those figures that are the participant projections of impingees. In general circumstances sortally constrain argument structures and the entire account of semantic compatibility is sensitive to this.

10. Conclusion

This paper has been an exploration of the architecture of an open-ended constructivist approach to lexical semantics based on the concept of a frame. Frames belong to narrowly defined semantic neighborhoods. Each frame describes a set of circumstances with fixed participants in fixed relations. Non-techical English will require somewhere on the order of several thousand. The larger question we have dressed in this work is how this open-ended inventory of concepts is realized through a relatively impoverished set of valences.

To explore the issue we've factored lexical semantic descriptions into two parts, separating *circumstances*, the basic situational information, from *argument structure*, which determines a valence. An argument structure presents a particular view of the circumstances, potentially factoring the semantic information into multiple predications. A process I have called participant projection governs the relationship between circumstance frames and argument frames. Participant projection is divided into two components, subscene projection and role abstraction. Subscene projection is essentially a way of viewing one kind of circumstance as another generally simpler kind, which can be directly projected into argument structure. We view a commercial event as a possession transfer (*buy*, *sell*) or as a resource consumption (*spend*), for example, and the possession transfer and resource consumption are projected into argument structure by abstraction relations that are independently motivated for those circumstances.

The directly projectable circumstances of the language provide a closed inventory of semantic templates it can use to realize lexical predicates, a set of argument constructions, in effect (in the sense of Goldberg (1995)). The projectable circumstances are in turn constrained by the marking devices of a language (such as prepositions with circumstance-specific sense), its canonicalized argument structures, and its abstraction relations.

The process of subscene projection provides part of the answer to the two-part question we started out with:

1. How do we account for core participants that are not arguments? (the case of the *seller* with *spend*)

2. How do we account for core arguments that are not participants? (the case of the *on*-phrase with *spend*).

The other part of the answer is sense transfer, which can change many aspects of a predicate, including its participants, Subscene projection and participant projection are governed by the entailment principle. Sense transfer is not.

[SENSE TRANSFER]

In order to get a bird's-eye view of the kind of lexicon advocated here, let us suppose that lexical items have frames as well, specializations of their argument structures frames with their relation attributes instantated. For example, the lexical frame for hit/2 is simply:

$$
(130)\quad \left[\begin{array}{ll} \textit{directed-motion} & \\ \text{rel} & \text{hit/2} \\ \text{goal} & \boxed{1} \\ \text{theme} & \boxed{2} \\ \text{resultant-location} & \left[\begin{array}{ll}\textit{location} & \\ \text{figure} & \boxed{2} \\ \text{ground} & \boxed{1}\end{array}\right] \\ \text{path} & \textbf{path}\end{array}\right]
$$

What the theory sketched in this paper amounts to is a large network of circumstance, argument frames, and lexical frames. The nodes are frames, the links between the nodes the relations we have featured in our account, inheritance, abstraction relations, subscene relations, and conventionalized causal connections. In order to simplify the issue of the interaction of inheritance with the other relations, imagine that inheriting frames simply copy all the relations of the frames they inherit from.

In the resulting picture, the nodes are not randomly and richly interconnected. Rather there seem to be small clusters of richly connected nodes. The verbs belong to the impingement frame are all clustered together via their connection to impingement and via the sense transfers to other valences. There is a single strand connecting the impingement verbs to the shape loss verbs, encoding their conventional causal connection. And there is another strand connecting impingement with caused movement, countenancing the hitting of balls over fences. Via that connection there is a connection with a host of other subnetworks that can cause movement. But there is no connection between this cluster and disappointment.

In this sense what we have is, as suggested at the outset, a semantic landscape. The circumstantial portion of that landscape is largely shared as we move from language to language. New nodes may enter in, but they will be connected by inheritance to old nodes. Nodes may disappear, but their connections may be passed the next node up the inheritance hierarchy. Conventional causal connections may change from language to language (as, famously, what may be caused motion changes), but largely the links will remain unaffected.

To the extent that this picture of stable circumstances may be sustained, frames provide a indispensable tool for the cross-linguistic comparison of lexicons.

11. Appendix: Notes on the logic and Notation

[First: review def of Domain of a relation; distinguish from its appropriateness set]

The following questions are all linked:

1. What does it mean for a **relation** to have an appropriateness set distinct from its domain? On the classic set of ordered pairs model of a relation, there is the set of the n-tuples in a relation's domain and the complement of that set. How do we model domain appropriateness as opposed to domain?

2. What does it mean for a relation to be "applied to" some appropriate entity not in its domain?

3. What does it mean for a role to be semantically optional?

11.1. Model

We model an n-ary sorted relation R as an $n+1$ tuple.

For example, a unary sorted relation R is a pair:

$$\mathrm{R} = \langle \mathrm{S}, \mathrm{Ext} \rangle$$

where Ext (extension) satisfies the following:

$$\mathrm{Ext} \subseteq \mathrm{S}.$$

A binary sorted relation R is a triple:

$$\mathrm{R} = \langle \mathrm{S}, \mathrm{T}, \mathrm{Ext} \rangle$$

where Ext (extension) satisfies the following:

$$\mathrm{Ext} \subseteq \mathrm{S} \times \mathrm{T}$$

Intuitively, S is the domain appropriateness set, T is the range appropriatenss set, and Ext is the set of ordered pairs that defines the extension of the relation.

We define natural extensions of relation composition and relation-inverse to sorted relations:

$$
\begin{aligned}
\mathrm{R}_1 \circ \mathrm{R}_2 = \langle \mathrm{S}_2,\ \mathrm{T}_1,\ \mathrm{Ext}\rangle,&\ \text{ where}\\
&\mathrm{R}_1 = \langle \mathrm{S}_1,\ \mathrm{T}_1,\ \mathrm{Ext}_1\rangle,\ \text{ and}\\
&\mathrm{R}_2 = \langle \mathrm{S}_2,\ \mathrm{T}_2,\ \mathrm{Ext}_2\rangle,\ \text{ and}\\
&\mathrm{Ext} = \{\langle x,\ y\rangle \mid \ \text{There exists } z \in \mathrm{T}_2 \bigcap \mathrm{S}_1\\
&\qquad\qquad\qquad\quad \text{such that } \mathrm{R}_2(x,z) \text{ and } \mathrm{R}_1(z,y)\}
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{R}^{-1} = \ &\langle \mathrm{T},\ \mathrm{S},\ \mathrm{Ext}^{-1}\rangle,\ \text{ where}\\
&\mathrm{R} = \langle \mathrm{S},\ \mathrm{T},\ \mathrm{Ext}\rangle \text{ and}\\
&\mathrm{Ext}^{-1} = \{\langle x,\ y\rangle \mid \ \langle y,\ x\rangle \in \mathrm{Ext}\}
\end{aligned}
$$

We also introduce the operation of restricting a relation to its domain sort:

$$
\begin{aligned}
\mathrm{R}\upharpoonleft = \ &\langle \mathrm{Dom},\ \mathrm{T},\ \mathrm{Ext}\rangle,\ \text{ where}\\
&\mathrm{R} = \langle \mathrm{S},\ \mathrm{T},\ \mathrm{Ext}\rangle \text{ and}\\
&\mathrm{Dom} = \{x \mid \ \text{There exists } y \in \mathrm{T} \text{ such that } \langle x,\ y\rangle \in \mathrm{Ext}\}
\end{aligned}
$$

Thus $\mathrm{R}\upharpoonleft$ is a relation with the same extension as R whose domain appropriateness set has been restricted to the domain of R (a subset of its orginal appropriateness set S).

Finally we define $\mathrm{R}^{\upharpoonleft}$:

$$\mathrm{R}^{\upharpoonleft} = (\mathrm{R}^{-1})\upharpoonleft$$

11.2. Logic

1. A set of relations
2. Function composition
3. Inverses
4. $\upharpoonleft$ operator
5. Equality

6. Congruence

7. $\geq$

Introduce primitive sort set S, primitive abstraction relation set AR, AR*, the sortal closure of S under AR*, which is called S*.

11.3. Semantic Incompatibility

An important feature of this account is that the semantics of sentences with incompatible modifiers is undefined. To repeat an example from the introduction:

(131) a. * John ate to school.
b. $\exists e[\mathrm{eat}(e) \wedge eater(e) = \mathrm{j} \wedge goal(e) = \mathrm{school}]$

The goal role is a function from motion events to their goals. Since an eating event is not a motion event, the semantics of (11) will be undefined.

At the same time, the treatment of ordinary selectional restrictions is left open.

(132)

a. John frightens sincerity.

b. $\exists e[\mathrm{frighten}(e) \wedge frightener(e) = \mathrm{j} \wedge experiencer(e) = \mathrm{sincerity}]$

Presumably the range of the *experiencer* role will be restricted to animates. But the exact semantic status of (132) will depend on the technical treatment of equality. If the selectional range of the "=" relation is unrestricted, then (132) will simply come out false.

The technical difference between (11) and (132) is that in the former the domain restriction of a role is being violated. It is the domain restriction of a modifier that determines what it can modify. Thus in principle violations of semantic compatibility of heads and modifiers can be distinguished from ordinary selectional violations.

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