Chapter 9

Argument structure and linking

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In this chapter, we discuss the nature and purpose of argument structure in HPSG, focusing on the problems that theories of argument structure are intended to solve, including: (1) the relationship between semantic arguments of predicates and their syntactic realizations, (2) the fact that lexical items can occur in more than one syntactic frame (so-called valence or diathesis alternations), and (3) argument structure as the locus of binding principles. We also discuss cases where the argument structure of a verb includes more elements than predicted from the meaning of the verb, as well as rationales for a lexical approach to argument structure.

1 Introduction

For a verb or other predicator to compose with the phrases or pronominal affixes expressing its semantic arguments, the grammar must specify the mapping between the semantic participant roles and syntactic dependents of that verb. For example, the grammar of English indicates that the subject of *eat* fills the eater role and the object of *eat* fills the role of the thing eaten. In HPSG, this mapping is usually broken down into two simpler mappings by positing an intermediate representation called ARG-ST (argument structure). The first mapping connects the participant roles within the semantic CONTENT with the elements

of the value of the ARG-ST feature; here we will call the theory of this mapping *linking theory* (see Section 4). The second mapping connects those ARG-ST list elements to the elements of the valence lists, namely COMPS (complements) and SUBJ (subject) and SPR (specifier); we will refer to this second mapping as *argument realization* (see Section 2).[1] These two mappings are illustrated with the simplified lexical sign for the verb *eat* in (1) (for ease of presentation, we use a standard predicate-calculus representation of the value of CONTENT in (1) rather than the attribute-value representation we introduce later on).

(1) Lexical sign for the verb *eat*:

$$\begin{bmatrix} \text{PHON} & \langle \textit{eat} \rangle \\ \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\,\text{NP}_i, \boxed{2}\,\text{NP}_j \rangle \\ \text{CONTENT} & \textit{eat}(i, j) \end{bmatrix}$$

In (1), "NP" abbreviates a feature description representing syntactic and semantic information about a nominal phrase. The variables i and j are the referential indices for the eater and eaten arguments, respectively, of the *eat* relation. The semantic information in NP_i semantically restricts the value or referent of i.

The ARG-ST feature plays an important role in HPSG grammatical theory. In addition to regulating the mapping from semantic arguments to grammatical relations, ARG-ST is the locus of the theories of anaphoric binding and other construal relations such as control and raising. (This chapter focuses on the function of ARG-ST in semantic mapping, with some discussion of binding and other construal relations only insofar as they interact with that mapping. A more detailed look at binding is presented in Müller (2024a), Chapter 20 of this volume. Control and raising is the topic of Chapter 12 (Abeillé 2024).)

In HPSG, verb diathesis alternations, voice alternations, and derivational processes such as category conversions are all captured within the lexicon (see Section 5 and Davis & Koenig 2024, Chapter 4 of this volume). The different variants of a word are grammatically related either through lexical rules or by means of the lexical type hierarchy. HPSG grammars explicitly capture paradigmatic relations between word variants, making HPSG a *lexical approach to argument structure*, in the sense of Müller & Wechsler (2014). This fundamental property of lexicalist theories contrasts with many transformational approaches, where such relationships are treated as syntagmatically related through operations on

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[1]Some linguists, such as Levin & Rappaport Hovav (2005), use the term "argument realization" more broadly, to encompass linking as well.

phrasal structures representing sentences and other syntactic constituents. Arguments for the lexical approach are reviewed in Section 8.

Within the HPSG framework presented here, we will formulate and address a number of empirical and theoretical questions:

- We know that a verb's meaning influences its valence requirements (via the ARG-ST list, on this theory). What are the principles governing the mapping from CONTENT to ARG-ST? Are some aspects of ARG-ST idiosyncratically stipulated for individual verbs? Which aspects of the semantic CONTENT bear on the value of ARG-ST, and which aspects do not? (For example, what is the role of modality?)

- How are argument alternations defined with respect to our formal system? For each alternation we may ask which of the following it involves: a shuffling of the ARG-ST list; a change in the mapping from ARG-ST to the valence lists; or a change in the CONTENT, with a concomitant change in the ARG-ST?

These questions will be addressed below in the course of presenting the theory. We begin by considering ARG-ST itself (Section 2), followed by the mapping from ARG-ST to valence lists (Section 3), and the mapping from CONTENT to ARG-ST (Section 4). The remaining sections address further issues relating to argument structure: the nature of argument alternations, extending the ARG-ST attribute to include additional elements, whether ARG-ST is a universal feature of languages, and a comparison of the lexicalist view of argument structure presented here with phrasal approaches.

2 The representation of argument structure in HPSG

In the earliest versions of HPSG, the selection of dependent phrases was specified in the SUBCAT feature of the head word (Pollard & Sag 1987, Pollard & Sag 1994: Chapters 1–8). The value of SUBCAT is a list of items, each of which corresponds to the SYNSEM value of a complement or subject. The following are SUBCAT features for an intransitive verb, a transitive verb, and a transitive verb with obligatory PP complement:

(2) a. *laugh*: [SUBCAT ⟨ NP ⟩]
    b. *eat*: [SUBCAT ⟨ NP, NP ⟩]
    c. *put*: [SUBCAT ⟨ NP, NP, PP ⟩]

Phrase structure rules in the form of immediate dominance schemata identify a certain daughter node as the head daughter (HEAD-DTR) and others, including subjects, as complement daughters (COMP-DTRS). In keeping with the *Subcategorization Principle*, here paraphrased from Pollard & Sag (1994: 34), list items are effectively "canceled" from the SUBCAT list as complement phrases, including the subject, are joined with the selecting head:

(3) Subcategorization Principle: In a headed phrase, the SUBCAT value of the HEAD-DTR (head daughter) is the concatenation of the phrase's SUBCAT list with the list of SYNSEM values of the COMPS-DTRS (complement daughters).

Phrasal positions are distinguished by their saturation level: "VP" is defined as a verbal projection whose SUBCAT list contains a single item, corresponding to the subject, and "S" is defined as a verbal projection whose SUBCAT list is empty.

The "subject" of a verb, a distinguished dependent with respect to construal processes such as binding, control, and raising, was then defined as the first item in the SUBCAT list, hence the last item with which the verb combines. However, defining "subject" as the last item to combine with the head proved inadequate (Pollard & Sag 1994: Chapter 9). There are many cases where the dependent displaying subject properties need not be the last item added to the head projection. For example, in German the subject is a nominal in nominative case (Reis 1982), but the language allows subjectless clauses containing only a dative or genitive non-subject NP. If that oblique NP is the only NP dependent to combine with the verb, then it is *ipso facto* the last NP to combine, yet such obliques lack the construal properties of subjects in German.

Consequently, the SUBCAT list was split into two valence lists, a SUBJ list of length zero or one for subjects, and a COMPS list for complements. Nonetheless, certain grammatical phenomena, such as binding and other construal processes, must still be defined on a single list comprising both subject and complements (Manning et al. 1999). Additionally, some syntactic arguments are unexpressed or realized by affixal pronouns, rather than as subject or complement phrases. The new list containing all the syntactic arguments of a predicator was named ARG-ST (argument structure).

In clauses without implicit or affixal arguments or extracted arguments, the ARG-ST is the concatenation of SUBJ and COMPS respectively. For example, the SUBCAT list for *put* in (2c) is replaced with the following:

$$(4) \quad \begin{bmatrix} \text{PHON} & \langle \textit{put} \rangle \\ \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2}, \boxed{3} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\,\text{NP}, \boxed{2}\,\text{NP}, \boxed{3}\,\text{PP} \rangle \end{bmatrix}$$

The idealization according to which ARG-ST is the concatenation of SUBJ and COMPS is canonized as the *Argument Realization Principle* (ARP) (Sag et al. 2003: 494). Systematic exceptions to the ARP, that is, dissociations between VALENCE and ARG-ST, are discussed in Section 3.2 below.

A predicator's valence lists indicate its requirements for syntactic concatenation with dependents (Section 3). ARG-ST, meanwhile, provides syntactic information about the expression of semantic roles and is related, via linking theory, to the lexical semantics of the word (Section 3.2). The ARG-ST list contains specifications for the union of the verb's local phrasal dependents (the subject and complements, whether they are semantic arguments, raised phrases, or expletives) and its arguments that are not realized locally, whether they are unbounded dependents, affixes, or unexpressed arguments.

Figure 1 provides a schematic representation of linking and argument realization in HPSG, illustrated with the verb *donate*, as in *Mary donated her books to the library*. Linking principles govern the mapping of participant roles in a predicator's CONTENT to elements of the ARG-ST list. Argument realization is shown in this figure only for mapping to valence, which represents locally realized phrasal dependents; affixal and null arguments are not depicted (but are discussed below). The ARG-ST and valence lists in this figure contain only arguments linked to participant roles, but in Section 6 we discuss proposals for extending ARG-ST to include additional elements. In Section 3, we examine cases where the relationship between ARG-ST and valence violates the ARP.

3 Argument realization: The mapping between ARG-ST and valence lists

3.1 Variation in the expression of arguments

The valence features SUBJ and COMPS are responsible for composing a verb with its dependents, but this is just one of the ways that semantic arguments of a verb are expressed in natural language. Semantic arguments can be expressed

Semantics
(CONTENT)
$$\begin{bmatrix} \textit{donate-rel} \\ \text{DONOR} \quad i \\ \text{RECIPIENT} \ j \\ \text{THEME} \quad k \end{bmatrix}$$
Semantic relation denoted by a verb

$\uparrow\downarrow$ *Linking Principles*

Argument Structure
(ARG-ST)
$$\begin{bmatrix} \text{ARG-ST} \ \langle \boxed{1}\text{NP}_i, \boxed{2}\text{NP}_k, \boxed{3}\text{PP}[\textit{to}]_j \rangle \end{bmatrix}$$
List of syntactic arguments of the verb

$\uparrow\downarrow$ *Argument Realization Principles*

Syntax (SUBJ/COMPS)
$$\begin{bmatrix} \text{SUBJ} \quad \langle \boxed{1}\text{NP}_i \rangle \\ \text{COMPS} \ \langle \boxed{2}\text{NP}_k, \boxed{3}\text{PP}[\textit{to}]_j \rangle \end{bmatrix}$$
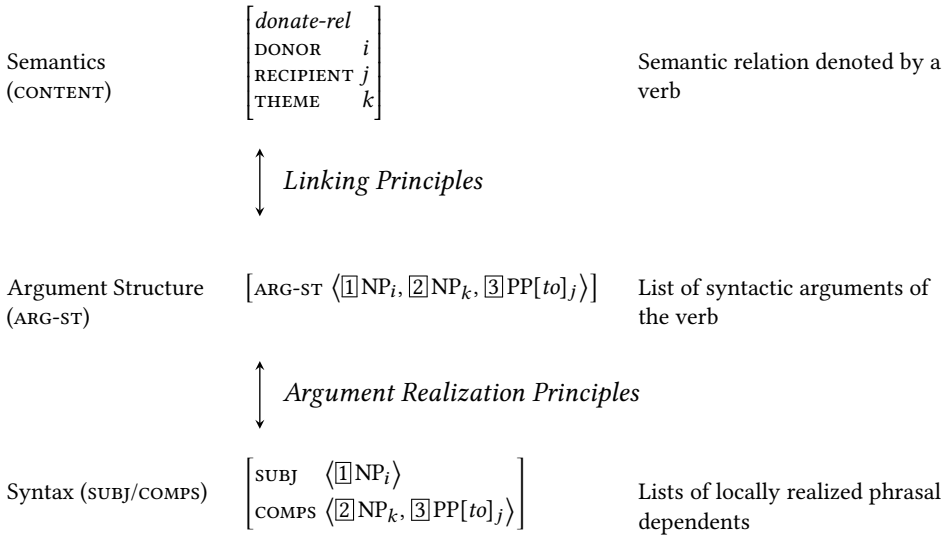Lists of locally realized phrasal dependents

Figure 1: Linking and argument realization in HPSG, illustrated with the verb *donate*

in various linguistic forms: as local syntactic dependents (SUBJ and COMPS), as affixes, or displaced in unbounded dependency constructions (SLASH).

Affixal arguments can be illustrated with the first person singular Spanish verb *hablo* 'speak.1SG', as in (5).

(5) a. Habl-o   español.   (Spanish)
        speak-1SG Spanish
        'I speak Spanish.'

   b. *hablo* 'speak.1SG':
$$\begin{bmatrix} \text{PHON} \quad \langle \textit{ablo} \rangle \\ \text{SUBJ} \quad \langle \rangle \\ \text{COMPS} \ \langle \boxed{2} \rangle \\ \text{ARG-ST} \ \left\langle \text{NP:} \begin{bmatrix} \textit{ppro} \\ \text{INDEX} \begin{bmatrix} \text{PERS } \textit{1st} \\ \text{NUM } \textit{sg} \end{bmatrix} \end{bmatrix}, \boxed{2}\text{NP} \right\rangle \end{bmatrix}$$

The *-o* suffix contributes the first person singular pronominal subject content to the verb form (the morphological process is not shown here; see Crysmann 2024, Chapter 21 of this volume). The pronominal subject (an NP with the semantic

content of type *ppro*, which stands for personal pronoun, see Müller 2024a: 957, Chapter 20 of this volume) appears on the ARG-ST list and hence is subject to the binding theory. But it does not appear in SUBJ, if no subject NP appears in construction with the verb.

A lexical sign whose ARG-ST list is just the concatenation of its SUBJ and COMPS lists conforms to the Argument Realization Principle (ARP); such signs are called *canonical signs* by Bouma et al. (2001). Non-canonical signs, which violate the ARP, have been approached in two ways. In one approach, a lexical rule takes as input a canonical entry and derives a non-canonical one by removing items from the valence lists, while adding an affix or designating an item as an unbounded dependent by placement on the SLASH list. In the other approach, a feature of each ARG-ST list item specifies whether the item is subject to the ARP (hence mapped to a valence list), or ignored by it (hence expressed in some other way). See Davis & Koenig (2024), Chapter 4 of this volume for more detail on the lexicon and Miller & Sag (1997) for a treatment of French clitics as affixes.[2]

A final case to consider is null anaphora, in which a semantic argument is simply left unexpressed and receives a definite pronoun-like interpretation. Japanese *mi-* 'see' is transitive but the object NP can be omitted as in (6).

(6) Naoki-ga mi-ta. (Japanese)
   Naoki-NOM see-PST
   'Naoki saw it/him/her/*himself.'

Null anaphors of this kind typically arise in discourse contexts similar to those that license ordinary weak pronouns, and the unexpressed object often has the obviation effects characteristic of overt pronouns, as shown in (6). HPSG eschews the use of silent formatives like "small *pro*" when there is no evidence for such items, such as local interactions with the phrase structure. Instead, null anaphors of this kind are present in ARG-ST but absent from valence lists. ARG-ST is directly linked to the semantic CONTENT and is the locus of Binding Theory, so the presence of a syntactic argument on the ARG-ST list but not a valence list accounts for null anaphora. To account for obviation, the ARG-ST list item, when unexpressed, receives the binding feature of ordinary (non-reflexive) pronouns, usually *ppro*. This language-specific option can be captured in a general way by valence and ARG-ST defaults in the lexical hierarchy for verbs.

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[2]There are several different versions of the ARP and non-canonical synsems are sometimes allowed within the value of SUBJ and COMPS, see among others Abeillé & Godard (2001: 19). We omit a full discussion of such differences in this chapter.

3.2 The syntax of ARG-ST and its relation to valence lists

The ordering of members of the ARG-ST list represents a preliminary syntactic structuring of the set of argument roles. In that sense, ARG-ST functions as an interface between the lexical semantics of the verb and the expressions of dependents as described in Section 3. Its role thus bears some relation to the initial stratum in Relational Grammar (Perlmutter & Postal 1984), *argument structure* (including intrinsic classifications) in LFG Lexical Mapping TheoryLexical Functional Grammar (Bresnan et al. 2016), macroroles in Role and Reference Grammar (Van Valin & LaPolla 1997), D-structure in Government and Binding Theory, and the Merge positions of arguments in Minimalism, assuming in the last two cases the Uniformity of Theta Assignment Hypothesis (UTAH) (Baker 1988: 46) or something similar. However, it also differs from all of those in important ways.

Semantic constraints on ARG-ST are explored in Section 4 below. But ARG-ST represents not only semantic distinctions between the arguments, but also syntactic ones. Specifically, the list ordering represents relative syntactic *obliqueness* of arguments. The least oblique argument is the subject (SUBJ), followed by the complements (COMPS). Following Manning (1996), term arguments (direct arguments, i.e., subjects and objects) are assumed to be less oblique than "oblique" arguments (adpositional and oblique case marked phrases), followed finally by predicate and clausal complements. The transitive ordering relation on the ARG-ST list is called *o-command* (obliqueness command): the list item that corresponds to the subject o-commands those corresponding to complements; a list item corresponding to an object o-commands those corresponding to any obliques; and so on (see Müller 2024a, Chapter 20 of this volume for details).

Relative obliqueness conditions a number of syntactic processes and phenomena, including anaphoric binding. The o-command relation replaces the c-command in the Principles A, B, and C of Chomsky's (1981) configurational theory of binding. For example, HPSG's Principle B states that an ordinary pronoun cannot be o-commanded by its coargument antecedent, which accounts for the pronoun obviation observed in the English sentence *Naoki$_i$ saw him$_{*i/j}$*, and also accounts for obviation in the Japanese sentence (6) above.

Relative obliqueness also conditions the accessibility hierarchy of Keenan & Comrie (1977), according to which a language allowing relativization of some type of dependent also allows relativization of any dependent less oblique than it. Hence if a language has relative clauses at all, it has subject relatives; if it allows obliques to relativize, then it also allows subject and object relatives; and so on. Similar implicational universals apply to verb agreement with subjects, objects, and obliques (Greenberg 1966).

Returning now to argument realization, we saw above that the rules for the selection of the subject from among the verb's arguments are also stated in terms of the ARG-ST list. In a canonical realization the subject is the first list item, o-commanding all of its coarguments. In various non-canonical circumstances, such as those we noted above, o-command relations do not correspond to ordering on the valence lists, and this can be reflected in phenomena such as anaphoric binding. In the following section we examine another kind of non-canonical relationship between ARG-ST and valence in more detail: syntactic ergativity, exemplified by Balinese.

3.3 Syntactic ergativity

The autonomy of ARG-ST from the valence lists is further illustrated by cross-linguistic variation in the mapping between them. As just noted, in English and many other languages, the initial item in ARG-ST maps to the subject. However, languages with so-called *syntactically ergative* clauses have been analyzed as following a different mapping rule. Crucially, the ARG-ST ordering in those languages is still supported by independent evidence from properties such as binding and NP versus PP categorial status of arguments. Balinese (Austronesian), as analyzed by Wechsler & Arka (1998), is such a language. In the morphologically unmarked, and most common voice, called *Objective Voice* (OV), the subject is any term *except* the ARG-ST-initial one.

Balinese canonically has SVO order, regardless of the verb's voice form (Artawa 1994, Wechsler & Arka 1998). The preverbal NPs in (7) are the surface subjects and the postverbal ones are complements. When the verb appears in the unmarked objective voice (OV), a non-initial term is the subject, as in (7a). But verbs in the *Agentive Voice* (AV) select as their subject the ARG-ST-initial item, as in (7b).

(7) a. Bawi adol   ida.   (Balinese)
         pig   OV.sell 3SG
         'He/She sold a pig.'

    b. Ida ng-adol bawi.
         3SG AV-sell pig
         'He/She sold a pig.'

A ditransitive verb, such as the benefactive applied form of *beli* 'buy' in (8), has three term arguments on its ARG-ST list. The subject can be either term that is non-initial in ARG-ST:

(8)   a.   Potlote   ento beli-ang=a   I   Wayan.   (Balinese)
           pencil.DEF that OV.buy-APPL=3 ART Wayan
           '(S)he bought Wayan the pencil.'

      b.   I   Wayan beli-ang=a   potlote   ento.
           ART Wayan OV.buy-APPL=3 pencil.DEF that
           '(S)he bought Wayan the pencil.'

Wechsler and Arka argue that Balinese voice alternations do not affect ARG-ST list order. Thus the agent argument can bind a coargument reflexive pronoun (but not vice versa), regardless of whether the verb is in OV or AV form:

(9)   a.   Ida   ny-ingakin ragan idane.   (Balinese)
           3SG AV-see   SELF
           '(S)he saw himself/herself.'

      b.   Ragan idane cingakin ida.
           SELF   OV.see   3SG
           '(S)he saw himself/herself.'

The 'seer' argument o-commands the 'seen', with the AV versus OV voice forms regulating subject selection:

(10)   Agentive Voice form of 'see':

$$\begin{bmatrix} \text{PHON} & \langle \textit{nyinkagin} \rangle \\ \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \boxed{2}\text{NP}_j \rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{see-rel} \\ \text{SEER } i \\ \text{SEEN } j \end{bmatrix} \end{bmatrix}$$

(11)   Objective Voice form of 'see':

$$\begin{bmatrix} \text{PHON} & \langle \textit{cinkagin} \rangle \\ \text{SUBJ} & \langle \boxed{2} \rangle \\ \text{COMPS} & \langle \boxed{1} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \boxed{2}\text{NP}_j \rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{see-rel} \\ \text{SEER } i \\ \text{SEEN } j \end{bmatrix} \end{bmatrix}$$

Languages like Balinese illustrate the autonomy of ARG-ST. Although the agent binds the patient in both (9a) and (9b), the binding conditions cannot be stated directly on the thematic hierarchy. For example, in HPSG a raised argument appears on the ARG-ST list of the raising verb, even though that verb assigns no thematic role to that list item. But a raised subject can bind a coargument reflexive in Balinese (this is comparable to English *John seems to himself to be ugly*). Anaphoric binding in Balinese raising constructions thus behaves as predicted by the ARG-ST based theory (Wechsler 1999). In conclusion, neither valence lists nor CONTENT provides the right representation for defining binding conditions, but ARG-ST fits the bill.

Syntactically ergative languages besides Balinese that have been analyzed as using an alternative mapping between ARG-ST and valence include Tagalog, Inuit, some Mayan languages, Chukchi, Toba Batak, Tsimshian languages, and Nadëb (Manning 1996, Manning et al. 1999).

Interestingly, while the GB/Minimalist configurational binding theory may be defined on analogues of the valence lists or CONTENT, those theories lack any analogue of ARG-ST. This leads to special problems for such theories in accounting for binding in many Austronesian languages like Balinese. In transformational theories since Chomsky (1981), anaphoric binding conditions are usually stated with respect to the A-positions (argument positions). A-positions are analogous to HPSG valence list items, with relative c-command in the configurational structure corresponding to relative list ordering in HPSG, in the simplest cases. Meanwhile, to account for data similar to (9), where agents asymmetrically bind patients, Austronesian languages like Balinese were said to define binding on the "thematic structure" encoded in d-structure or Merge positions, where agents asymmetrically c-command patients regardless of their surface positions (Guilfoyle et al. 1992). But the interaction with raising shows that neither of those levels is appropriate as the locus of binding theory (Wechsler 1999).[3]

3.4 Symmetrical objects

We have thus far tacitly assumed a total ordering of elements on the ARG-ST list, but Ackerman, Malouf & Moore (2013, 2017) propose a partial ordering for certain so-called *symmetrical object languages*. In Moro (Kordofanian), the two term complements of a ditransitive verb have exactly the same object properties.

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[3]To account for (9b) under the configurational binding theory, the subject position must be an A-bar position, but to account for binding by a raised subject, it must be an A-position. See Wechsler (1999) and the discussion of this paper in Müller (2024a: Section 5), Chapter 20 of this volume.

Relative linear order of the theme and goal arguments is free, as shown by the two translations of (12) (from Ackerman et al. 2017: 9; CL 'noun class'; SM 'subject marker).

(12) é-g-a-natʃ-ó   óráŋ   ŋeɾá   (Moro)
      1SG.SM-CLg-MAIN-give-PFV CLg.man CLŋ.girl
      'I gave the girl to the man.' / 'I gave the man to the girl.'

More generally, the two objects have identical object properties with respect to occurrence in post-predicate position, case marking, realization by an object marker, and ability to undergo passivization (Ackerman et al. 2017: 9).

   Ackerman et al. (2017: 33) propose that the two objects are unordered on the ARG-ST list. Their modified Argument Realization Principle (p. 34) allows for two different mappings to the COMPS list, as shown here:

(13)   a. Goal argument as primary object:

$$\begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{2}, \boxed{3} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \{\boxed{2}\text{NP}_j, \boxed{3}\text{NP}_k\} \rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{give-rel} \\ \text{AGENT } i \\ \text{GOAL} \quad j \\ \text{THEME } k \end{bmatrix} \end{bmatrix}$$

       b. Theme argument as primary object:

$$\begin{bmatrix} \text{SUBJ} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{3}, \boxed{2} \rangle \\ \text{ARG-ST} & \langle \boxed{1}\text{NP}_i, \{\boxed{2}\text{NP}_j, \boxed{3}\text{NP}_k\} \rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{give-rel} \\ \text{AGENT } i \\ \text{GOAL} \quad j \\ \text{THEME } k \end{bmatrix} \end{bmatrix}$$

The primary object properties, which are associated with the initial term argument of COMPS, can go with either the goal or theme argument.

   To summarize this section, while the relationship between ARG-ST, SUBJ, and COMPS lists was originally conceived as a straightforward one, enabling binding principles to maintain their simple form by defining ARG-ST as the concatenation of the other two, the relationship was soon loosened. Looser relationships

between ARG-ST and the valence lists are invoked in accounts of several core syntactic phenomena. Arguments not realized overtly in their canonical positions due to extraction, cliticization, or pro-drop (null anaphora) appear on ARG-ST but not in any valence list. Accounts of syntactic ergativity in HPSG involve variations in the mapping between ARG-ST and valence lists; in particular, the element of SUBJ is not, in such languages, the first element of ARG-ST. Modifications of ARG-ST play a role in some treatments of passivization, where its expected first element is suppressed, and in languages with multiple, symmetric objects, where a partial rather than total ordering of ARG-ST elements has been postulated (see Section 5.3 for details on the analysis of passives in HPSG). Thus ARG-ST has now acquired an autonomous status within HPSG, and is not merely a predictable rearrangement of information present in the valence lists.

4 Linking: the mapping between semantics and ARG-ST

4.1 HPSG approaches to linking

The term *linking* refers to the mapping specified in a lexical entry between participant roles in the semantics and their syntactic representations on the ARG-ST list. Early HPSG grammars stipulated the linking of each verb: semantic CONTENT values with predicator-specific attributes like DEVOURER and DEVOURED were mapped to the subject and object, respectively, of the verb *devour*. But linking follows general patterns across verbs, and across languages; e.g., if one argument of a transitive verb in active voice has an agentive role, it will map to the subject, not the object, except in syntactically ergative languages described in Section 3.3 above, and in those languages the linking is just as regularly reversed. Those early HPSG grammars did not capture the regularities across verbs.

To capture those regularities, HPSG researchers beginning with Wechsler (1995a) and Davis (1996) formulated linking principles stated on more general semantic properties that hold across verbs.

Within the history of linguistics, there have been three general approaches to modeling the lexico-semantic side of linking: thematic role types (Pāṇini ca. 400 B.C., Fillmore 1968); lexical decomposition (Foley & Van Valin 1984, Rappaport Hovav & Levin 1998); and the proto-roles approach (Dowty 1991). In developing linking theories within the HPSG framework, Wechsler (1995a) and Davis (1996) employed a kind of lexical decomposition that also incorporated some elements of the proto-roles approach. The reasons for preferring this over the alternatives are discussed in Section 4.4 below.

Wechsler's (1995a) linking theory constrains the relative order of pairs of arguments on the ARG-ST list according to semantic relations entailed between them. For example, his *notion rule* states that if one participant in an event is entailed to have a mental notion of another, then the first must precede the second on the ARG-ST list. The *conceive-pred* type is defined by the following type declaration (based on Wechsler 1995a: 127, with formal details adjusted for consistency with current usage):

(14) *conceive-pred*:

$$
\begin{bmatrix}
\text{ARG-ST} & \langle \text{NP}_i, \text{NP}_j \rangle \\
\text{CONTENT} &
\begin{bmatrix}
\textit{conceive-rel} \\
\text{CONCEIVER } i \\
\text{CONCEIVED } j
\end{bmatrix}
\end{bmatrix}
$$

This accounts for a host of linking facts in verbs as varied as *like*, *enjoy*, *invent*, *claim*, and *murder*, assuming these verbs belong to the type *conceive-pred*. It explains the well-known contrast between experiencer-subject *fear* and experiencer-object *frighten* verbs: *fear* entails that its subject has some notion of its object, so *The tourists feared the lumberjacks* entails that the tourists are aware of the lumberjacks. But the object of *frighten* need not have a notion of its subject: in *The lumberjacks frightened the tourists (by cutting down a large tree that crashed right in front of them)*, the tourists may not be aware of the lumberjacks' existence.

Two other linking rules appear in Wechsler (1995a). One states that "affected themes", that is, participants that are entailed to undergo a change, map to the object, rather than subject, of a transitive verb. Another states that when stative transitive verbs entail a part-whole relation between the two participants, the whole maps to the subject and the part to the object: for example, *X includes Y* and *X contains Y* each entail that *Y* is a part of *X*.

These linking constraints do not rely on a total ordering of thematic roles, nor on an exhaustive assignment of thematic role types to every semantic role in a predicator. Instead, a small set of partial orderings of semantic roles, based on lexical entailments, suffices to account for the linking patterns of a wide range of verbs. This insight was adopted in a slightly different guise in work by Davis (1996), Davis (2001), and Davis & Koenig (2000), who develop a more elaborated representation of lexical semantics, with which simple linking constraints can be stated. The essence of this approach is to posit a small number of dyadic semantic relations such as *act-und-rel* (actor-undergoer relation) with attributes ACT(OR) and UND(ERGOER) that serve as intermediaries between semantic roles and syn-

tactic arguments (akin to the notion of Generalized Semantic Roles discussed in Van Valin 1999).

What are the truth conditions of *act-und-rel*? Following Fillmore (1977), Dowty (1991), and Wechsler (1995a), Davis & Koenig note that many of the pertinent lexical entailments come in related pairs. For instance, one of Dowty's entailments is that one participant causally affects another, and of course the other is entailed to be causally affected. Another involves the entailments in Wechsler's notion rule (14); one participant is entailed to have a notion of another. These entailments of paired participant types characterize classes of verbs (or other predicators), and can then be naturally represented as dyadic relations in CONTENT. Collecting those entailments, we arrive at a disjunctive statement of truth conditions:

(15) *act-und-rel*(x, y) is true iff x causes a change in y, or x has a notion of y, or …

We can designate the x participant in the pair as the value of ACTOR (or ACT) and y as the value of UNDERGOER (or UND), in a relation of type *act-und-rel*. Semantic arguments that are ACTOR or UNDERGOER will then bear at least one of the entailments characteristic of ACTORS or UNDERGOERS (Davis & Koenig 2000: 72). This then simplifies the statement of linking constraints for all of these paired participant types. Davis (1996) and Koenig & Davis (2001) argue that this obviates counting the relative number of proto-agent and proto-patient entailments, which is what Dowty (1991) had advocated.

The linking constraints (16) and (17) state that a verb whose semantic CONTENT is of type *act-und-rel* will be constrained to link the ACT participant to the the first element of the verb's ARG-ST list (its subject), and the UND participant to the second element of the verb's ARG-ST list (this is analogous to Wechsler's constraints based on partial orderings). The attribute KEY selects one predication as relevant for linking, among a set of predications included in a lexical item's CONTENT; we furnish more details below.

These linking constraints can be viewed as parts of the definition of lexical types, as in Davis (2001), where each of the constraints in (16)–(18) defines a particular class of lexemes (or words).[4]

---

[4]Alternatively, (16) (and other linking constraints) can be recast as implicational constraints on lexemes or words (Koenig & Davis 2003). (i) is an implicational constraint indicating that a word whose semantic content includes an ACTOR role must map that role to the initial item in the ARG-ST list.

(i) $\left[\text{CONTENT|KEY} \left[\text{ACT} \; \boxed{1} \right] \right] \Rightarrow \left[\text{ARG-ST} \left\langle \text{NP}_{\boxed{1}}, \ldots \right\rangle \right]$

(16)
$$\begin{bmatrix} \text{CONTENT|KEY} \begin{bmatrix} \text{ACT} \boxed{1} \end{bmatrix} \\ \text{ARG-ST} \left\langle \text{NP}_{\boxed{1}}, ... \right\rangle \end{bmatrix}$$

(17)
$$\begin{bmatrix} \text{CONTENT|KEY} \begin{bmatrix} \text{UND} \boxed{2} \end{bmatrix} \\ \text{ARG-ST} \left\langle ..., \text{NP}_{\boxed{2}}, ... \right\rangle \end{bmatrix}$$

(18)
$$\begin{bmatrix} \text{CONTENT|KEY} \begin{bmatrix} \textit{cause-possess-rel} \\ \text{SOA} \begin{bmatrix} \text{ACT} \boxed{3} \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} \left\langle \textit{synsem} \right\rangle \oplus \left\langle \text{NP}_{\boxed{3}}, ... \right\rangle \end{bmatrix}$$

The first constraint, in (16), links the value of ACT (when not embedded within another attribute) to the first element of ARG-ST. The second, in (17), merely links the value of UND (again, when not embedded within another attribute) to some NP on ARG-ST. Given this understanding of how the values of ACT and UND are determined, these constraints cover the linking patterns of a wide range of transitive verbs: *throw* (ACT causes motion of UND), *slice* (ACT causes change of state in UND), *frighten* (ACT causes emotion in UND), *imagine* (ACT has a notion of UND), *traverse* (ACT "measures out" UND as an incremental theme), and *outnumber* (ACT is superior to UND on a scale).

The third constraint, in (18), links the value of an ACT attribute embedded within a SOA (state of affairs) attribute to an NP that is second on ARG-ST. This constraint accounts for the linking of the (primary) object of ditransitives. In English, these verbs (*give*, *hand*, *send*, *earn*, *owe*, etc.) involve (prospective) causing of possession (Pinker 1989, Goldberg 1995), and the possessor is represented as the value of the embedded ACT in (18). There could be additional constraints of a similar form in languages with a wider range of ditransitive constructions; conversely, such a constraint might be absent in languages that lack ditransitives entirely. As mentioned earlier in this section, the range of subcategorization options varies somewhat from one language to another.

The KEY attribute in (16)–(18) also requires further explanation. The formulation of linking constraints here employs the architecture used in Koenig & Davis (2006), in which the semantics represented in CONTENT values is expressed as a set of *elementary predications*, in a way similar to and inspired by Minimal Recursion Semantics (Copestake et al. 2001, 2005). Each elementary predication is a simple relation, but the relationships among them may be left unspecified. For linking, one of the elementary predications is designated the KEY, and it serves as the locus of linking. This allows us to indicate the linking of participants that play multiple roles in the denoted situation. The KEY selects one relation as the

"focal point," and the other elementary predications are then irrelevant as far as linking is concerned. The choice of KEY then becomes an issue demanding consideration; we will see in the discussion of argument alternations in Section 5 how this choice might account for some alternation phenomena.

These linking constraints apply to word classes in the lexical hierarchy (see Davis & Koenig 2024, Chapter 4 of this volume). One consequence of this fact merits brief mention. Constraint (17), which links the value of UND to some NP on ARG-ST, is a specification of one class of verbs. Not all verbs (and certainly not all other predicators, such as nominalizations) with a CONTENT value containing an UND value realize it as an NP. Verbs obeying this constraint include the transitive verbs noted above, and intransitive "unaccusative" verbs such as *fall* and *persist*. But some verbs with both ACT and UND attributes in their CONTENT are intransitive, such as *impinge (on)*, *prevail (on)*, and *tinker (with)*. Interactions with other constraints, such as the requirement that verbs (in English, at least) have an NP subject, determine the range of observed linking patterns.

These linking constraints also assume that the proto-role attributes ACTOR, UNDERGOER, and SOA are appropriately matched to entailments, as described above. Other formulations are possible, such as that of Koenig & Davis (2003), where the participant roles pertinent to each lexical entailment are represented in CONTENT by corresponding, distinct attributes.

In addition to the linking constraints, there may be some very general well-formedness conditions on linking. We rarely find verbs that obligatorily map one semantic role to two distinct members of the ARG-ST list, both expressed overtly. A verb meaning 'eat', but with that disallowed property, could appear in a ditransitive sentence like (19), with the meaning that Pat ate dinner, and his dinner was a large steak.

(19) * Pat ate dinner a large steak.

Typically, semantic arguments map to at most one (overtly expressed) ARG-ST list item (Davis 2001: 262–268).

Having set out some general principles of linking and their implementation in HPSG, we now briefly discuss linking of oblique arguments. We also return in the remainder of this section to issues relating to lexical semantic representations as they pertain to linking. To what extent are the elements of ARG-ST determined by lexical semantics? Do HPSG lexical semantic representations require thematic roles? And how does other information in these representations, such as modality and modifier scope, affect linking?

4.2 Linking oblique arguments

In this section we discuss linking of oblique arguments, that is, PPs and oblique case marked NPs. In some instances, a verb's selection of a particular preposition appears at least partly arbitrary; it is hard to explain why English speakers accept *hanker after* and *yearn for*, but not **yearn after*. In these cases, the choice of preposition may be stipulated by the individual lexical entry. But as Gawron (1986) and Wechsler (1995b) have shown, many prepositions selected by a verb have semantic content. *For* in the above-mentioned cases, and in *look for*, *wait for*, and *aim for*, is surely not a lexical accident. And in cases like *cut with*, *with* is used in an instrumental sense, denoting a *use-rel* relation, as with verbs that either allow (*eat*) or require (*cut*) an instrument (Koenig & Davis 2006). Davis (1996, 2001) adopts the position of Gawron and Wechsler in his treatment of linking to PPs. As an example of this kind of account, the linking type in (20) characterizes a verb selecting a *with*-PP. The PP argument is linked from the RELS list rather than the KEY.

$$
(20) \quad
\begin{bmatrix}
\text{CONTENT} &
\begin{bmatrix}
\text{KEY} & \boxed{1} \\
\text{RELS} & \left\langle \boxed{1}, \boxed{2}
\begin{bmatrix}
\textit{use-rel} \\
\text{ACT} & a \\
\text{UND} & u \\
\text{SOA} & s
\end{bmatrix}, \ldots \right\rangle
\end{bmatrix} \\
\text{ARG-ST} & \left\langle \ldots, \text{PP}_{with}{:}\boxed{2}, \ldots \right\rangle
\end{bmatrix}
$$

Apart from the details of individual linking constraints, we have endeavored here to describe how linking can be modeled in HPSG using the same kinds of constraints used ubiquitously in the framework. Within the hierarchical lexicon (see Davis & Koenig 2024, Chapter 4 of this volume), constraints between semantically defined classes and syntactically defined ones can furnish an account of linking patterns, and there is no resort to additional mechanisms such as a thematic hierarchy or numerical comparison of entailments.

4.3 To what extent does meaning predict linking?

The framework outlined above allows us to address the following question: how much of linking is strictly determined by semantic factors, and how much is left open to lexically arbitrary subcategorization specifications, or perhaps subject to other factors?

Subcategorization – the position and nature of ARG-ST elements, in HPSG terms – is evidently driven to a great extent by semantics, but debate continues

about how much, and which components of semantics are involved. Views have ranged from the strict, highly constrained relationship in which lexical semantics essentially determines syntactic argument structure to a looser one in which some elements of subcategorization may be stipulated. Among the first camp are those who espouse the Uniformity of Theta Assignment Hypothesis proposed in Baker (1988: 46), which maintains that "identical thematic relationships between items are represented by identical structural relationships" in the syntax (see also Baker 1997). With regard to the source of diathesis alternations, Levin (1993: 12–13) notes that "studies of these properties suggest that argument structures might in turn be derivable to a large extent from the meaning of words", and accordingly "pursues the hypothesis of semantic determinism seriously to see just how far it can be taken".

Others, including Pollard & Sag (1987: Section 5.3) and Davis (2001: Section 5.1), have expressed caution, pointing out cases where subcategorization and diathesis alternations seem to be at least partly arbitrary. Pollard & Sag (1987: ex. 214–215) note contrasts like these:

(21)   a.   Sandy spared/*deprived Kim a second helping.
       b.   Sandy *spared/deprived Kim of a second helping.

And Davis (2001: ex. 5.4) provides these pairs of semantically similar verbs with differing subcategorization requirements:

(22)   a.   Few passengers waited for/awaited the train.
       b.   Homer opted for/chose a chocolate frosted donut.
       c.   The music grated on/irritated the critics.

Other cases where argument structure seems not to mirror semantics precisely include raising constructions, in which one of a verb's direct arguments bears no semantic role to it at all. Similarly, overt expletive arguments cannot be seen as deriving from some participant role in a predicator's semantics. Like the examples above, these phenomena suggest that some aspects of subcategorization are specified independently of semantics.

Another point against strict semantic determination of argument structure comes from cross-linguistic observations of subcategorization possibilities. It is evident, for example, that not all languages display the same range of direct argument mappings. Some lack ditransitive constructions entirely (Halkomelem), some allow them across a limited semantic range (English), some quite generally (Georgian), and a few permit tritransitives (Kinyarwanda and Moro). Gerdts

(1992) surveys about twenty languages and describes consistent patterns like these. The range of phenomena such as causative and applicative formation in a language is constrained by what she terms its "relational profile"; this includes, in HPSG terms, the number of direct NP arguments permitted on its ARG-ST lists. Again, it is unclear that underlying semantic differences across languages in the semantics of verbs meaning *give* or *write* would be responsible for these general patterns.

4.4 HPSG and thematic roles

The ARG-ST list constitutes the syntactic side of the mapping between semantic roles and syntactic dependents. As ARG-ST is merely an ordered list of arguments, without any semantic "labels", it contains no counterparts to thematic role types, such as AGENT, PATIENT, THEME, or GOAL. Thematic roles like these, however, have been a mainstay of linking in Generative Grammar since Fillmore (1968) and have antecedents going back to Pāṇini. Ranking them in a *thematic hierarchy*, and labeling each of a predicator's semantic roles (e.g., EATER and FOOD for the verb *eat*) with a unique thematic role (e.g., AGENT and PATIENT for *eat*), then yields an ordering of roles analogous to the ordering on the ARG-ST list. Indeed, it would not be difficult to import this kind of system into HPSG, as a means of determining the order of elements on the ARG-ST list. However, HPSG researchers have generally avoided using a thematic hierarchy, for reasons we now briefly set out.

Fillmore (1968) and many others thereafter have posited a small set of disjoint thematic roles, with each of a predicator's participant roles assigned exactly one thematic role. Thematic hierarchies depend on these properties for a consistent linking theory, but they do not hold up well to formal scrutiny. Jackendoff (1987) and Dowty (1991) note (from somewhat different perspectives) that numerous verbs have arguments not easily assigned a thematic role from the typically posited inventory (e.g., the objects of *risk*, *blame*, and *avoid*), that more than one argument might sensibly be assigned the same role (e.g., the subjects and objects of *resemble*, *border*, and some alternants of commercial transaction verbs), and that multiple roles can be sensibly assigned to a single argument (the subjects of verbs of volitional motion such as *jump* or *flee* are both an AGENT and a THEME). In addition, consensus on the inventory of thematic roles has proven elusive, and some, notoriously THEME, have resisted clear definition. Work in formal semantics, including Ladusaw & Dowty (1988), Dowty (1989), Landman (2000), and Schein (2002), casts doubt on the prospects of assigning formally defined thematic roles to all of a predicator's arguments, at least in a manner that would

allow them to play a crucial part in linking. Thematic role types seem to pose problems, and there are alternatives that avoid those problems. As Carlson (1998: 35) notes about thematic roles: "It is easy to conceive of how to write a lexicon, a syntax, a morphology, a semantics, or a pragmatics without them". The three attributes ACT, UND, and SOA can capture most of what needs to be stated about linking direct arguments within HPSG. There is thus no need to posit a more extensive range of thematic roles. Moreover, because the same participant can be referenced by more than one of these attributes, it is simple to distinguish within lexical representations between, e.g., caused volitional motion or change of state (as in *jump* or *dress*), in which the values of ACT and UND are identical, and "unaccusative" verbs (such as *fall* or *vanish*), which lack an ACT in their CONTENT. In the following sections, we will see additional examples of these attributes in more complex lexical semantic representations.

4.5 CONTENT decomposition and ARG-ST

Instead of thematic role types, lexical decomposition is typically used in HPSG to model the semantic side of the linking relation. The word meaning represented by the CONTENT value is decomposed into elementary predications that share arguments, as described in Section 4.1 above and Section 5 below. Lexical decompositions cannot be directly observed, but the decompositions are justified indirectly by the roles they play in the grammar. Decompositions play a role in at least the following processes:

- *Linking.* As described in Section 4.1, linking constraints are stated on semantic relations like *act-und-rel* (actor-undergoer relation), so those relations must be called out in the CONTENT value.

- *Sublexical scope.* Certain modifiers can scope over a part of the situation denoted by a verb (Dowty 1979).

Consider sentence (23).

(23)   John sold the car, and then he bought it again.

In this sentence, the adverb *again* either adds the presupposition that John bought it before, or, in the more probable interpretation, it adds the presupposition that *the result of buying the car* obtained previously. The result of buying a car is owning it, so this sentence presupposes that John previously owned the car. Thus the decomposition of the verb *buy* includes a *possess-rel* (possession relation) holding

between the buyer and the goods. This is available for modification by adverbials like *again*.

- *Argument alternations.* Some argument alternations can be modeled as the highlighting of different portions of a single lexical decomposition. See Section 5.

In general, sublexical decompositions are included in the CONTENT value only insofar as they are visible to the grammar for processes like these.

The ARG-ST list lies on the syntax side of linking. Just as the roles and predicates within CONTENT must be motivated by (linguistic) semantic considerations, the presence of elements on ARG-ST is primarily motivated by their syntactic visibility. Many ARG-ST list items are obviously justified, being explicitly expressed as subject and complement phrases, or as affixal pronouns. In addition, certain implicit arguments should appear on ARG-ST if, for instance, they are subject to the binding theory constraints that apply to ARG-ST, as discussed in Section 3.1 above.

Some implicit arguments can also participate in the syntax, for example, by acting as controllers of adjunct clauses. This could plausibly be viewed as evidence that such arguments are present on the ARG-ST list. English rationale clauses, like the infinitival phrase in (24a), are controlled by the agent argument in the clause, *the hunter* in this example. The implicit agent of a short passive can likewise control the rationale clause as shown in (24b). But control is not possible in the middle construction (24c) even though loading a gun requires some agent. This contrast was observed by Keyser & Roeper (1984) and confirmed in experimental work by Mauner & Koenig (2000).

(24) a. The shotgun was loaded quietly by the hunter to avoid the possibility of frightening off the deer.
      b. The shotgun was loaded quietly to avoid the possibility of frightening off the deer.
      c. * The shotgun had loaded quietly to avoid the possibility of frightening off the deer.

If the syntax of control is specified such that the controller of the rationale clause is an (agent) argument on the ARG-ST list of the verb, then this contrast is captured by assuming that the agent appears on the ARG-ST list of the passive verb but not the middle.

4.6 Modal transparency

Another observation concerning lexical entailments and linking was developed by Koenig & Davis (2001), who point out that linking appears to ignore modal elements of lexical semantics, even when those elements invalidate entailments (expanding on an observation implicit in Goldberg 1995). For instance, there are various English verbs that display linking patterns like the ditransitive verbs of possession transfer *give* and *hand*, but which denote situations in which the transfer need not, or does not, take place. Consider (25). Thus, *offer* describes a situation where the transferor is willing to effect the transfer, *owe* one in which the transferor should effect the transfer but has not yet, *promise* describes a situation where the transferor commits to effect the transfer, and *deny* one in which the transferor does not effect the contemplated transfer.

(25) Marge offered/owed/promised/denied Homer a chocolate donut.

Koenig & Davis argue that modal elements should be clearly separated in CONTENT values from the representations of predicators and their arguments. (26) exemplifies this factoring out of sublexical modal information from core situational information.

(26) The lexical semantic representation of *promise* (Koenig & Davis 2001: 101):

$$
\begin{bmatrix}
\textit{promise-sem} \land \textit{cause-possess-sem} \\[2pt]
\text{SIT-CORE} \quad \boxed{1}
\begin{bmatrix}
\textit{cause-possess-rel} \\
\text{ACT} \quad a \\
\text{UND} \quad \boxed{2} \\
\text{SOA} \quad
\begin{bmatrix}
\text{SIT-CORE}
\begin{bmatrix}
\textit{have-rel} \\
\text{ACT} \quad \boxed{2} \\
\text{UND} \quad u
\end{bmatrix}
\end{bmatrix}
\end{bmatrix} \\[2pt]
\text{MODAL-BASE} \left\langle
\begin{bmatrix}
\textit{deontic-mb} \land \textit{condit-satis-mb} \\
\text{SOA} \quad \boxed{1}
\end{bmatrix}
\right\rangle
\end{bmatrix}
$$

This pattern of linking functioning independently of sublexical modal information applies not only to these ditransitive cases, but also to verbs involving possession (cf. *own* and *obtain* vs. *lack*, *covet*, and *lose*), perception (*see* vs. *ignore* and *overlook*), and carrying out an action (*manage* vs. *fail* and *try*). Whatever the role of lexical entailments in linking, then, the modal components should be factored out, since the entailments that determine, e.g., the ditransitive linking patterns of verbs like *give* and *hand* do not hold for *offer*, *owe*, or *deny*, which display the same linking patterns. The constraints in (16)–(18) need only be minimally

altered to target the value of SIT-CORE, representing the "situational core" of a relation.

This kind of semantic decomposition preserves the simplicity of linking constraints, while representing the differences between verbs that straightforwardly entail the relation between the arguments in the situational core and verbs for which those entailments do not hold, because their meaning contains a modal component restricting those entailments to a subset of possible worlds.

4.7 Summary of linking

In this section we have examined HPSG approaches to linking. HPSG constrains the mapping between participant roles in CONTENT and their syntactic representation on ARG-ST based on entailments of the semantic relations in CONTENT. These constraints do not require a set of thematic roles arranged in a hierarchy. Nor do they require a numerical comparison of entailments holding for each participant role, which has been an influential alternative to a thematic hierarchy. Rather, they reference the types of relations within a lexical entry's CONTENT, and the subcategorization requirements of its ARG-ST. Information from both is necessary because, although semantics is a strong determinant of argument realization, independent stipulations of subcategorization appear to be needed, too. Finally, we have examined the role of modal information in lexical semantics, which seem not to interact much with linking, and described mechanisms proposed within HPSG that separate this information from the situational core that drives linking.

In the remainder of this chapter, we will examine the relationship of argument structure to argument alternations, including passives, as well as broader questions concerning the addition of other elements like modifiers to ARG-ST, the universality of ARG-ST across languages, and whether ARG-ST is best regarded as solely a lexical attribute or one that should also apply to phrases or constructions.

5 The semantics and linking of argument alternations

A single verb can often alternate between various alternative patterns of dependent phrases, a situation called either *argument alternations*, *valence alternations*, or *diathesis alternations*. Levin (1993) lists around 50 kinds of alternations in English, and English is not untypical in this regard.

How has argument structure in HPSG been used to account for alternations? Many alternations exhibit (often subtle) meaning differences between the two

alternants. We first discuss alternations due to these differences in meaning, showing how their differing ARG-ST lists arise from differences in CONTENT. We then examine some alternations where meaning differences are less apparent. Although the CONTENT values of the two alternants in such cases may not differ, we can analyze the alternation in terms of a different choice of KEY predicate in each. Lastly, we consider active-passive voice alternations, which are distinct from other alternations in important ways.

5.1 Meaning-based argument alternations

One well-studied alternation, the locative alternation, is exemplified by the two uses of *spray* in (27).

(27) a. *spray*_{loc}: Joan sprayed the paint onto the statue.
      b. *spray*_{with}: Joan sprayed the statue with paint.

It is typically assumed that these two different uses of *spray* in (27) have slightly different meanings, with the statue being in some sense more affected in the *with* alternant. This exemplifies the "holistic" effect of direct objecthood, which we will return to. Here, we will examine how semantic differences between alternants relate to their linking patterns. The semantic side of linking has often been devised with an eye to syntax (e.g., Pinker 1989, and see Koenig & Davis 2006 for more examples). There is a risk of stipulation here, without independent evidence for these semantic differences. In the case of locative alternations, though, the meaning difference between (27a) and (27b) is easily stated (and Pinker's intuition seems correct), as (27b) entails (27a), but not conversely. Informally, (27a) describes a particular kind of caused motion situation, while (27b) describes a situation in which this kind of caused motion additionally results in a caused change of state. The difference is depicted in the two structures in (28).

(28) a. CAUSE (JOAN, GO (PAINT, TO (STATUE)))
      b. ACT-ON (JOAN, STATUE, BY (CAUSE (JOAN, GO (PAINT, TO (STATUE)))))

This description of the semantic difference between sentences (27a) and (27b) provides a strong basis for predicting their different argument structures. But we still need to explain how linking principles give rise to this difference. Pinker's account rests on semantic structures like (28), in which depth of embedding reflects sequence of causation, with ordering on ARG-ST stemming from depth of semantic embedding, a strategy adopted in Davis (1996) and Davis (2001). This is

one reasonable alternative, although the resulting complexity of some of the semantic representations raises valid questions about what independent evidence supports them. An alternative appears in Koenig & Davis (2006), who borrow from Minimal Recursion Semantics (see Koenig & Richter 2024: Section 6.1, Chapter 22 of this volume for an introduction to MRS). MRS "flattens" semantic relations, rather than embedding them in one another, so the configuration of these *elementary predications* with respect to one another is of less import. It posits a RELATIONS (or RELS) attribute that collects a set of elementary predications, each representing some part of the predicator's semantics. In Koenig & Davis' analysis, a KEY attribute specifies a particular member of RELS as the relevant one for linking (of direct syntactic arguments). In the case of (27b), the KEY is the caused change of state description. These MRS-style representations of the two alternants of *spray*, with different KEY values, are shown in (29) and (30).

$$
(29) \quad
\begin{bmatrix}
\text{KEY} \enspace \boxed{5} \\[2pt]
\text{RELS} \enspace \left\langle \boxed{5}
\begin{bmatrix}
spray\text{-}ch\text{-}of\text{-}loc\text{-}rel \\
\text{ACT} \enspace \boxed{1} \\
\text{UND} \enspace \boxed{4} \\
\text{SOA} \enspace
\begin{bmatrix}
ch\text{-}of\text{-}loc\text{-}rel \\
\text{FIGURE} \enspace \boxed{4}
\end{bmatrix}
\end{bmatrix}
\right\rangle
\end{bmatrix}
$$

$$
(30) \quad
\begin{bmatrix}
\text{KEY} \enspace \boxed{3} \enspace
\begin{bmatrix}
spray\text{-}ch\text{-}of\text{-}st\text{-}rel \\
\text{ACT} \enspace \boxed{1} \\
\text{UND} \enspace \boxed{2} \\
\text{SOA} \enspace
\begin{bmatrix}
ch\text{-}of\text{-}st\text{-}rel \\
\text{UND} \enspace \boxed{2}
\end{bmatrix}
\end{bmatrix} \\[6pt]
\text{RELS} \enspace \left\langle \boxed{3},
\begin{bmatrix}
use\text{-}rel \\
\text{ACT} \enspace \boxed{1} \\
\text{UND} \enspace \boxed{4} \\
\text{SOA} \enspace \boxed{3}
\end{bmatrix},
\begin{bmatrix}
spray\text{-}ch\text{-}of\text{-}loc\text{-}rel \\
\text{ACT} \enspace \boxed{1} \\
\text{UND} \enspace \boxed{4} \\
\text{SOA} \enspace
\begin{bmatrix}
ch\text{-}of\text{-}loc\text{-}rel \\
\text{FIGURE} \enspace \boxed{4}
\end{bmatrix}
\end{bmatrix}
\right\rangle
\end{bmatrix}
$$

Generalizing from this example, one possible characterization of valence alternations, implicit in Koenig & Davis (2006), is as systematic relations between two sets of lexical entries in which the RELS of any pair of related entries are in a subset/superset relation (a weaker version of that definition would merely require an overlap between the RELS values of the two entries). Consider another case; (31) illustrates the causative-inchoative alternation, where the intransitive alternant describes only the change of state, while the transitive one ascribes an explicit causing agent.

(31)   a. John broke the window.
       b. The window broke.

Under an MRS representation, the change of state relation is a separate member of RELS; it is also included in the RELS of the transitive alternant, which contains a cause relation as well. Again, the RELS value of one member of each pair of related entries is a subset of the RELS value of the other.

Many other alternations involve one argument shifting from direct to oblique. Some English examples include conative, locative preposition drop, and *with* preposition drop alternations, as shown in (32):

(32)   a. Rover clawed (at) Spot.
       b. Bill hiked (along/on) the Appalachian Trail.
       c. Burns debated (with) Smithers.

The direct object argument in (32a) is interpreted as more "affected" than its oblique counterparts: if Rover clawed Spot, we infer that Spot was subjected to direct contact with Rover's claws and may have been injured by them, while if Rover merely clawed *at* Spot, no such inference can be made. Similarly, to say that one has hiked the Appalachian Trail as in the transitive variant of (32b) suggests that one has hiked its entire length, while the prepositional variants merely suggest one hiked along some portion of it. In still other cases like (32c), the two variants seem to differ very little in meaning.

Beavers (2010) observes the following generalization over direct–oblique alternations: the direct variant entails the oblique one, and can have an additional entailment that the oblique variant lacks. His *Morphosyntactic Alignment Principle* (MAP) states this generalization in terms of "L-thematic roles", which are defined as sets of entailments associated with individual thematic roles:

(33)   When participant *x* may be realized as either a direct or oblique argument of verb V, it bears L-thematic role R as a direct argument and L-thematic role $Q \subseteq_M R$ as an oblique. (Beavers 2010: 848)

Here, Q and R are roles, defined as sets of individual entailments, and $Q \subseteq_M R$ means that set Q is a subset of R that is minimally different from R, differing in at most one entailment. Thus, the substantive claim is essentially that the MAP rules out "verbs where the alternating participant has MORE lexical entailments as an oblique than the corresponding object realization" (Beavers 2010: 849). The notion of a stronger role in Beavers' analysis has a rough analogue in

terms of whether a particular elementary predication is present in the semantics of a particular alternant. Beavers (2005) describes a version of the Morphosyntactic Alignment Principle implemented in HPSG, which posits a separate ROLES attribute within CONTENT, containing a list of labeled roles. The roles are ordered on the ROLES list, determined at least partly by direction of causality, although this is not fully worked out. Each role can be regarded as a bundle of entailments. The bundle of entailments varies slightly between different alternants of verbs like those in (32), and the Morphosyntactic Alignment Principle comes into play, comparing the sets of entailments constituting each role. Assessing which of two roles is stronger, according to this principle, requires some additional mechanisms within HPSG that are not spelled out.

Beavers notes the resemblance between his account and numerical comparison approaches such as those of Dowty (1991) and Ackerman & Moore (2001). He points out that the direct object bears an additional entailment in each alternant. However, the specific entailment involved depends on the verb; the entailments involved in each of the examples in (32), for instance, are all different. Thus, comparing the numbers of entailments holding for a verb's arguments in each alternant is crucial.

5.2 Relationships between alternants

Having outlined the semantic basis of the different linking patterns of alternating verbs, we briefly take up two other issues. First is the question of how the alternants are related to one another. Second is how KEY selection has been used to account not just for alternants of the same verb, but for (nearly) synonymous verbs whose semantics contain the same set of elementary predications.

The hypothesis pursued in Davis (1996) and Davis (2001) is that most alternations are the consequence of classes of lexical entries having two related meanings. This follows researchers such as Pinker (1989) and Levin (1993) in modeling subcategorization alternations as underlyingly meaning alternations. This change in meaning is crucial to the Koenig & Davis (2006) KEY shifts as well. In some cases, the value of the RELS attribute of the two valence alternates differ (as in the two alternates of *spray* in the so-called *spray/load* alternation we discussed earlier). In some cases, the alternation might be different construals of the same event for some verbs, but not others, as Rappaport Hovav & Levin (2008) claim for the English ditransitive alternation, which adds the meaning of transfer for verbs like *send*, but not for verbs like *promise*; a KEY change would be involved (with the addition of a *cause-possess-rel*) for the first verb only. But KEY shifts and diathesis alternations do not always involve a change in meaning. The same

elementary predications can be present in the CONTENT values of two alternants, with each alternant designating a different elementary predication as the KEY.

Koenig & Davis propose this not only for cases in which there is no obvious meaning difference between two alternants of a single verb, but also for different verbs that appear to be truth-conditionally equivalent. The verbs *substitute* and *replace* are one such pair. The two sentences in (34) illustrate this equivalence.

(34) a. They substituted an LED for the burnt-out incandescent bulb.
      b. They replaced the burnt-out incandescent bulb with an LED.

These two verbs denote a type of event in which a new entity takes the place of an old one, through (typically intentional) causal action. Koenig & Davis decompose both verb meanings into two simpler actions of removal and placement: 'x removes y (from g)' and 'x places z (at g)', each represented as an elementary predication in the CONTENT values of these verbs. In the following two structures, adapted from their work, the *location-rel* predication represents an entity being in a location, with the value of FIG denoting the entity and the value of GRND its location.

(35) Representation of 'x places y (at g)':

$$
\boxed{a} = \begin{bmatrix} \textit{place-rel} \\ \text{ACT } \boxed{1} \, (\text{x}) \\ \text{UND } \boxed{2} \, (\text{y}) \\ \text{SOA} \begin{bmatrix} \textit{location-sem} \\ \text{SIT-CORE} \begin{bmatrix} \textit{location-rel} \\ \text{FIG} \quad \boxed{2} \\ \text{GRND } g \end{bmatrix} \\ \text{MODAL-BASE } \langle \rangle \end{bmatrix} \end{bmatrix}
$$

(36) Representation of 'x removes z (from g)'

$$
\boxed{b} = \begin{bmatrix} \textit{remove-rel} \\ \text{ACT } \boxed{1} \, (\text{x}) \\ \text{UND } \boxed{3} \, (\text{z}) \\ \text{SOA} \begin{bmatrix} \textit{location-sem} \\ \text{SIT-CORE} \quad \boxed{4} \begin{bmatrix} \textit{location-rel} \\ \text{FIG} \quad \boxed{3} \\ \text{GRND } g \end{bmatrix} \\ \text{MODAL-BASE } \left\langle \begin{bmatrix} \textit{neg-rel} \\ \text{SOA } \boxed{4} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}
$$

Either one can be selected as the KEY. In the lexical entry of *replace*, the removal predication is the value of KEY, while in the lexical entry of *substitute*, the placement of the new object is the value of KEY. (37) and (38) show the CONTENT values of these two verbs under this account, where $\boxed{a}$ and $\boxed{b}$ abbreviate the structures in (35) and (36). In both cases, the same linking constraints apply between the KEY and the ARG-ST list, but the two verbs have different argument realizations because their KEY values differ, even though their semantics are equivalent.

(37) CONTENT value of *substitute for*:
$$\begin{bmatrix} \text{KEY} & \boxed{a} \\ \text{RELS} & \langle \boxed{a}, \boxed{b} \rangle \end{bmatrix}$$

(38) CONTENT value of *replace with*:
$$\begin{bmatrix} \text{KEY} & \boxed{b} \\ \text{RELS} & \langle \boxed{a}, \boxed{b} \rangle \end{bmatrix}$$

As a final example of the effect of alternations on fine-grained aspects of verb meaning, we consider the source-final product alternation exemplified in (39), where the direct object can be either the final product or the material source of the final product.

(39) a. Kim made/carved/sculpted/crafted a toy (out of the wood).
      b. Kim made/carved/sculpted/crafted the wood into a toy.

Davis proposes that the (39a) sentences involve an alternation between the two meanings represented in (40), each associated with a distinct entry. We adapt Davis (2001) to make it consistent with Koenig & Davis (2006) and also treat the alternation as an alternation of *entries* with distinct meanings. Lexical rules are a frequent analytical tool used to model alternations between two related meanings of a single entry illustrated in (40). One of the potential drawbacks of a lexical rule approach to valence alternations is that it requires selecting one alternant as basic and the other as derived. This is not always an easy decision, as Goldberg (1991: 731–732) or Levin & Rappaport Hovav (1994) have pointed out (e.g., is the inchoative or the causative basic?). Sometimes, morphology provides a clue, although in different languages the clues may point in different directions. French, and other Romance languages, use a "reflexive" clitic as a detransitivizing affix. In English, though, there is no obvious "basic" form or directionality. It is to avoid committing ourselves to a directionality in the relation between the semantic contents described in (40) that we eschew treating it as a lexical rule. (Identically numbered tags in (40a) and (40b) indicate structure-sharing and labels such as *final-product* and *source material* are informal and added for clarity.)

(40) a. $\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \text{KEY} & \boxed{3} \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{SOA} & \boxed{2} \text{ (final product)} \end{bmatrix} \\ \text{RELS} & \left\langle \boxed{3}, \boxed{4} \right\rangle \end{bmatrix} \end{bmatrix}$

b. $\begin{bmatrix} \text{CONTENT} & \begin{bmatrix} \text{KEY} & \boxed{4} \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{UND (source material)} \\ \text{SOA} & \begin{bmatrix} \textit{affect-incr-th-rel} \\ \text{ACT} & \boxed{1} \\ \text{SOA} & \boxed{2} \text{ (final product)} \end{bmatrix} \end{bmatrix} \\ \text{RELS} & \left\langle \boxed{3}, \boxed{4} \right\rangle \end{bmatrix} \end{bmatrix}$

5.3 The problem of passives

Although most diathesis alternations can be modeled as alternations in meaning or as KEY shifts, some arguably cannot. One prominent example is the active/passive alternation. Other widely attested constructions, such as raising constructions, similarly involve no change in meaning, but we will examine only passives here.

The semantics of actives and corresponding long passives, as in (41), are practically identical and the difference between the two alternants is pragmatic in nature.

(41) a. Fido dug a couple of holes.
b. A couple of holes were dug by Fido.

In this section, we outline two possible approaches to the passive. Both of them treat the crucial characteristic of passivization as subject demotion (see Blevins 2003 for a thorough exposition of this characterization), rather than object advancement, as proposed, e.g., in Relational Grammar (Perlmutter & Postal 1983). As we will see, there are various options for implementing this general idea of demotion within HPSG.

The first approach, which goes back to Pollard & Sag (1987: 215), assumes that passivization targets the first member of a SUBCAT list and either removes it or optionally puts it last on the list, but as a PP. This approach is illustrated in (42), a possible formulation of a lexical rule for transitive verbs adapted to a theory that replaces SUBCAT with ARG-ST, as discussed in Manning et al. (1999: 67). See Müller (2003) for a more refined formulation of the passive lexical rule for German that

accounts for impersonal passives, and Blevins (2003) for a similar analysis. The first NP is demoted and either does not appear on the output's ARG-ST or is a PP coindexed with the input's first NP's index.

Linking in passives thus violates the constraints in (16)–(18), specifically (16), which links the value of ACT to the first element of ARG-ST. We use one possible feature-based representation for lexical rules to help comparing approaches to passives. See Meurers (2001) and Davis & Koenig (2024: Section 5), Chapter 4 of this volume for a discussion of various approaches to lexical rules. Note that we use the attribute LEX-DTR rather than the IN(PUT) attribute used in the representation of lexical rules in Meurers (2001: 76), as, like him, we wish to avoid any procedural implications; nothing substantial hinges on this labeling change.[5]

(42)   Passive lexical rule:
$$\begin{bmatrix} passive\text{-}verb \\ \text{ARG-ST} \quad \boxed{1} \left(\oplus \left\langle \text{PP}[by]_i \right\rangle \right) \\ \text{LEX-DTR} \begin{bmatrix} stem \\ \text{HEAD} \quad verb \\ \text{ARG-ST} \left\langle \text{NP}_i \right\rangle \oplus \boxed{1} \left\langle \text{NP}, \dots \right\rangle \end{bmatrix} \end{bmatrix}$$

We will refer to this approach as the non-canonical linking analysis of passives. This kind of analysis invites at least three questions. First, as already noted, the constraint linking the value of ACT to the first element of ARG-ST is violated. If passives — widespread and hardly exotic constructions — violate canonical linking constraints, how strong an account of linking can be maintained? Second, what other predictions, such as changes in binding behavior, control constructions, and discourse availability, arise from the altered ARG-ST of passives? Third, what is the status of the *by*-phrase in long passives, and how is it represented on the ARG-ST list?

Another approach maintains the ARG-ST list of the active verb in its passive counterpart, thereby preserving linking constraints. Passives differ from actives under this account in their non-canonical mapping from ARG-ST to valence lists; the subject is not the first element of the ARG-ST list. This analysis bears some resemblance to the distinction between macro-roles and syntactic pivots in Role and Reference Grammar, with passives having a marked mapping from macro-roles to syntactic pivot (Van Valin & LaPolla 1997). In this kind of approach, the

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[5]A common way of depicting lexical rules uses the ↦ symbol. INPUT ↦ OUTPUT relates two lexical items. INPUT corresponds to the LEX-DTR and OUTPUT to the complete sign. Again see Davis & Koenig (2024: Section 5), Chapter 4 of this volume for details.

passive subject might be the second element of the ARG-ST list, as in a typical personal passive, or an expletive element, as in impersonal passives. In a long passive, the first element of ARG-ST is coindexed with a PP on the COMPS list or an adjunct. This analysis is reminiscent of the account of Balinese objective voice presented in Section 3.3 in that the account of both phenomena uses a non-canonical mapping between ARG-ST and valence lists. A version of this view is proposed by Davis (2001: 246), who suggests the representation in (43) for passive lexemes (as before, we substitute the attribute name LEX-DTR for IN).

(43) Passive lexical rule:

$$
\begin{bmatrix}
\textit{passive-verb} \\
\text{SUBJ} & \boxed{1} \\
\text{COMPS} & \boxed{2} \\
\text{ARG-ST} & \boxed{3}\,(\langle\,\text{XP}\,\rangle) \oplus \boxed{1} \oplus \boxed{2} \\
\text{CONTENT} & \boxed{4} \\
\text{LEX-DTR} & \begin{bmatrix} \textit{trans-stem} \\ \text{ARG-ST} & \boxed{3} \\ \text{CONTENT} & \boxed{4} \end{bmatrix}
\end{bmatrix}
$$

We will refer to this as the non-canonical argument realization analysis of passives. Again, at least three issues must be addressed. First, the standard mapping between the elements of ARG-ST and those of the valence lists is violated. If passives violate these canonical mapping constraints, how strong an account of the relationship between ARG-ST and valence can be maintained? Second, as with the non-canonical linking analysis, what predictions, such as changes in binding behavior, control constructions, and discourse availability, arise from the non-canonical valence values in passives? Third, what is the status of the *by*-phrase in long passives, and how is it represented on the ARG-ST list? If the logical subject remains the first element of a passive verb's ARG-ST list, does it appear as an additional oblique element on ARG-ST as well?

The implications of weakening canonical constraints under each of these analyses have not been thoroughly addressed, to our knowledge. We are unaware, for example, of proposals that limit non-canonical linking in HPSG to only the kind observed in passives. One might begin by stipulating that linking concerns only NP (i.e., "direct") arguments on ARG-ST, but the implications of this have not yet been well explored. Another possibility is to limit where linking constraints can apply. They might be restricted to apply to words whose MORPH or BASE feature values are of type *lexeme* not *word* (Runner & Aranovich 2003: 362) or they might apply to basic (underived) lexemes only, but not to their derived passive forms (this is the strategy adopted by the CoreGram project, Müller 2015).

Difficulties might arise in the latter case, however, in cases where derived forms add directly linked arguments, such as morphological causatives and applicatives. Müller (p. c. 2021) therefore assumes that when a lexical rule alters semantics – as in causatives and applicatives, but not passives – linking constraints must apply to its output. With respect to the non-canonical argument realization analysis, the required variation in ARG-ST to valence mappings has been investigated somewhat more (see Section 3 for some details), especially in connection with ergativity and voice alternations, and also in analyses of pro-drop, cliticization, and extraction (Miller & Sag 1997, Manning et al. 1999, Bouma et al. 2001). Thus, there are some independent motivations for positing non-canonical mappings between ARG-ST and valence lists. But we will leave matters here in regard to the general advantages and drawbacks of non-canonical linking versus non-canonical argument realization.

As for passives in particular, the two analyses make different predictions regarding binding and control by the "logical subject" (the subject of the corresponding actives). Under the non-canonical linking analysis, it is not present on the ARG-ST (and valence) lists of short passives, so it is predicted to be unavailable to any syntactic process that depends on elements of ARG-ST. Binding and varieties of control that reference these elements therefore cannot involve the logical subject. Under the non-canonical argument realization analysis, the logical subject is present on the ARG-ST lists of short passives, so it is predicted to play much the same role in binding as it does in corresponding actives. However, we can see that, at least when unexpressed, this is not the case, as in (44).

(44)   * The money was sent to himself. (himself intended to refer to the sender)

Certain control constructions also illustrate this point. While the unexpressed logical subject can control rationale clauses in English, as exemplified above in (24b), not all cases of control exhibit parallel behavior. The Italian consecutive *da* + infinitive construction (Perlmutter 1984, Sanfilippo 1998) appears to be controlled by the surface subject, as shown in (45).

(45)   a.   Gino ha rimproverato Eva tante   volte da   arrabbiarsi. (Italian)
             Gino has scolded   Eva so.many times so.as to.get.angry
             'Gino scolded Eva so many times that he/*she got angry.'
       b.   Eva fu   rimproverata da Gino tante   volte da   arrabbiarsi.
             Eva was scolded   by Gino so.many times so.as to.get.angry
             'Eva was scolded by Gino so many times that *he/she got angry.'

Although there are other factors involved in the choice of controller of consecutive *da* infinitive constructions, it is clear that the logical subject in the passivized

main clause cannot control the infinitive. Thus, even if it remains the initial element of the passive verb's ARG-ST, it must be blocked as a controller. Sanfilippo argues from these kinds of examples that the passive *by*-phrase should be regarded as a "thematically bound" (i.e., linked) adjunct that does not appear on the passive verb's ARG-ST list, but on the SLASH list. However, this would require some additional mechanism to explain the involvement of the *by*-phrase in binding, noted below, and possibly with respect to other evidence for including adjuncts on ARG-ST, as discussed in Section 6.

In addition, the implicit agent of short passives is "inert" in discourse, as discussed in Koenig & Mauner (1999). It cannot serve as an antecedent of cross-sentential pronouns without additional inferences, as shown in (46), where the referent of *he* cannot without additional inference be tied to the logical subject argument of *killed*, i.e., the killer.

(46)   # The president$_i$ was killed. He$_j$ was from Iowa.

Note that the discourse inertness of the implicit agent in (46) does not follow from its being unexpressed, as shown by the indefinite use of the subject pronoun *on* in French (Koenig 1999: 241–244) or Hungarian bare singular objects (Farkas & de Swart 2003: 89–108). These, though syntactically expressed, do not introduce discourse referents either. In such cases, as well as in passives under the non-canonical argument realization analysis, the first member of the ARG-ST list must therefore be distinguished from indices that introduce discourse referents.

These facts would seem to favor the non-canonical linking analysis. However, there are options for representing the inertness of the logical subject under the non-canonical argument realization analysis. One possibility is to introduce a special subtype of the type *index*, which we could call *inert* or *null*; by stipulation, it could not correspond to a discourse referent. This is also one way to treat the inertness of expletive pronouns, so it has some plausible independent motivation. Unlike expletive pronouns, the logical subject of passives is linked to an index in CONTENT. Its person and number features therefore cannot be assigned as defaults (e.g., third person singular *it* and *there* in English), but must correspond to those of the entity playing the relevant semantic role in CONTENT. Davis (2001: 251–253) offers a slightly different alternative using the dual indices INDEX and A-INDEX, following the distinction between AGR and INDEX used in Kathol (1999: 240–250) to model different varieties of agreement. The A-INDEX of a passive verb's logical subject is of type *null*, which, by stipulation, can neither o-command other members of ARG-ST nor appear on valence lists. In both impersonal and short personal passives, the logical subject is coindexed with a role in CONTENT representing an unspecified human (or animate). These analyses of logical subject inertness have not been pursued, however.

Finally, we turn to *by*-phrases in long passives. In languages like English, a *by*-phrase can express the lexeme's logical subject. Under both the non-canonical linking and non-canonical argument realization analyses, this might be represented as an optional oblique complement on ARG-ST, as indicated in (42) and (43), respectively. As noted, the non-canonical argument realization analysis would then posit that the ARG-ST of passives includes two members that correspond to the same argument, which again shows the need for an inert first element of ARG-ST. Another possibility is to treat such *by*-phrases as adjuncts (and therefore not part of the ARG-ST list), see Höhle (1978: Chapter 7) and Müller (2003: 292–294) for German and Jackendoff (1990: 180) for English. There is evidence, however, that *by*-phrases can serve as antecedents of anaphors in at least some languages. Collins (2005: 111) cites sentences like (47), which suggest that the complement of *by*-phrases can bind a reciprocal.

(47)   The packages were sent by the children to each other.

Acceptability judgements of this and similar examples vary, but they are certainly not outright unacceptable. Likewise, Perlmutter (1984: 10) furnishes Russian examples in which the logical subject (realized as an instrumental case NP) binds a reflexive (note that the English translation of it is also fairly acceptable).

(48)   Eta kniga byla kuplena Boris-om$_i$ dlja sebja$_i$.   (Russian)
         this book was bought Boris-INS for self
         'This book was bought by Boris$_i$ for himself$_i$.'

Given that binding is a relation between members of the ARG-ST list, such data would seem problematic for an approach that does not include *by*-phrases on the ARG-ST list. Interestingly, Perlmutter also argues that Russian *sebja* is subject-oriented (see Müller 2024a: Section 4, Chapter 20 of this volume). The intrumental NP *Borisom* can bind *sebja*, only because it corresponds to the subject of active *kupit'*, 'buy'. Assuming that is correct, an HPSG account of Russian passives would need some means of representing the logical subjecthood of these instrumental NPs; this might involve some way of accessing their active counterpart's SUBJ value, or of referencing the first element of the passive verb's ARG-ST list, despite its inertness.

The interaction of binding and control with passivization across languages appears to be varied, and as we have noted, we are not aware of systematic investigations into this variation and possible accounts of it within HPSG. Here, we have surveyed these phenomena and two possible approaches, while noting

that some key issues remain unresolved. Notably, both of these approaches introduce non-canonical lexical items, violating either linking or argument realization constraints that otherwise have strong support. Further work is required to assure that these can be preserved in a meaningful way, as opposed to allowing non-canonical structures to appear freely in the lexicon.

5.4 Summary

We have examined in this section several approaches to argument alternations in HPSG and their implications for ARG-ST. For alternations based on semantic differences, different alternants will have different CONTENT values, and linking principles like those we outlined in the previous section account for their syntactic differences. Even where such meaning differences are small, there are differing semantic entailments that can affect linking. For some cases where there seems to be no discernible meaning difference between alternants, it is still possible for linking principles to yield syntactic differences, if the alternants select different KEY predications in CONTENT. The active/passive alternation, however, cannot be accounted for in such a fashion, as it applies to verbs with widely varying CONTENT values. HPSG accounts of passives therefore resort to lexical items that are non-canonical, either in their linking or in their mapping between ARG-ST and valence. Both of these are ways of modeling the demotion of the logical subject. But there is as yet no consensus within the HPSG community on the correct analysis of passives.

6 Extended ARG-ST

Most of this chapter focuses on cases where semantic roles linked to the ARG-ST list are arguments of the verb's core meaning. But in quite a few cases, complements (or even subjects) of a verb are not part of this basic meaning; consequently, the ARG-ST list must be extended to include elements beyond the basic meaning. We consider three cases here, illustrated in (49)–(51).

Resultatives, illustrated in (49), express an effect, which is caused by an action of the type denoted by the basic meaning of the verb. The verb *fischen* 'to fish' is a simple intransitive verb (49a) that does not entail that any fish were caught, or any other specific effect of the fishing (see Müller 2002: 219–220).

(49)   a.   dass er fischt   (German)
            that he fishes
            'that he is fishing'

b. dass er ihn leer   fischt
   that he it   empty fishes
   'that he is fishing it empty'

c. wegen   der Leerfischung der   Nordsee[6]
   because.of the empty.fishing of.the.GEN North.See
   'because of the North Sea being fished empty'

In (49b) we see a resultative construction with an object NP and an adjectival secondary predicate. The meaning is that he is fishing, causing it (the body of water) to become empty of fish. Müller (2002: 241) posits a lexical rule for German applying to the verb that augments the ARG-ST list with an NP and AP, and adds the causal semantics to the CONTENT (see Wechsler 2005 for a similar analysis of English resultatives and Müller 2018: Section 7.2.3 for an updated lexical rule and interactions with benefactives). The existence of deverbal nouns like *Leerfischung* 'fishing empty', which takes the body of water as an argument in genitive case (see (49c)) confirms that the addition of the object is a lexical process, as noted by Müller (2002).

Romance clause-union structures as in (50) have long been analyzed as cases where the arguments of the complement of a clause-union verb (*faire* in (50)) are complements of the clause-union verb itself (Aissen 1979).

(50) Johanna a   fait   manger les enfants.   (French)
    Johanna has made eat   the children
    'Johanna had the children eat.'

Within HPSG, the "union" of the two verbs' dependents is modeled via the composition of ARG-ST lists of the clause union verb, following Hinrichs & Nakazawa (1994) (this is a slight simplification; see Godard & Samvelian 2024, Chapter 11 of this volume for details).

Abeillé & Godard (1997) have argued that many adverbs including *souvent* in (51) and negative particles or adverbs in French are complements of the verb, and Kim & Sag (2002) extended that view to some uses of negation in English. Such analyses hypothesize that some semantic modifiers are realized as complements, and thus should be added as members of ARG-ST (or members of the DEPS list, if one countenances such an additional list; see below). In contrast to resultatives, which affect the meaning of the verb, or to clause union, where one verb co-opts the argument structure of another verb, what is added to the ARG-ST list in these

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[6]die tageszeitung, 1996-06-20, p. 6.

cases is typically considered a semantic adjunct and a modifier in HPSG (thus it selects the verb or VP via the MOD attribute).

(51) Mes amis   m' ont   souvent aidé.   (French)
      my   friends me have often   helped
      'My friends often helped me.'

Another case of an adjunct that behaves like a complement is found in (52), taken from (Koenig & Davis 2006: 81). The clitic *en* expressing the cause of death is not normally an argument of the verb *mourir* 'die', but rather an adjunct:

(52) Il en   est mort.   (French)
      he of.it is   dead.PFV.PST
      'He died of it.'

On the widespread assumption (at least within HPSG) that pronominal clitics are verbal affixes (Miller & Sag 1997), the adjunct cause of the verb *mourir* must be represented within the entry for *mourir*, so as to trigger affixation by *en*. Bouma et al. (2001) discuss cases where "adverbials", as they call them, can be part of a verb's lexical entry. To avoid mixing those adverbials with the argument structure list (and having to address their relative obliqueness with syntactic arguments of verbs), they introduce an additional list, the dependents list (abbreviated as DEPS) which includes the ARG-ST list but also a list of adverbials. Each adverbial selects for the verb on whose DEPS list it appears as a dependent, as shown in (53). But, of course, not all verb modifiers can be part of the DEPS list,[7] and Bouma, Malouf & Sag discuss at length some of the differences between the two kinds of "adverbials".

(53) $verb \Rightarrow$ $\begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{CONT|KEY} & \boxed{2} \\ \text{DEPS} & \boxed{3} \oplus list\left(\begin{bmatrix} \text{MOD} & \begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{KEY} & \boxed{2} \end{bmatrix} \end{bmatrix}\right) \\ \text{ARG-ST} & \boxed{3} \end{bmatrix}$

Although the three cases we have outlined result in an extended ARG-ST, the ways in which this extension arises differ. In the case of resultatives, the extension results partly or wholly from changing the meaning in a way similar to

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[7]See Müller (1999: Section 20.4.1) and Müller (2024a: Section 6.1), Chapter 20 of this volume for possible binding conflicts arising when adjuncts within the nominal domain are treated this way.

Rappaport Hovav & Levin (1998): by adding a causal relation, as in for example (54), the effect argument of this causal relation is added to the membership in the base ARG-ST list (see Section 5 for a definition of the attributes KEY and RELS; here it suffices to note that a *cause-rel* is added to the list of relations that are the input of the lexical rule).

$$(54) \quad \begin{bmatrix} \text{KEY} & \boxed{1} \\ \text{RELS} & \boxed{2} \ \langle ..., \boxed{1}, ... \rangle \end{bmatrix} \mapsto \begin{bmatrix} \text{KEY} & \boxed{3} \ \textit{cause-rel} \\ \text{RELS} & \boxed{2} \oplus \langle \boxed{3} \rangle \end{bmatrix}$$

The entries of the clause union verbs are simply stipulated to include on their ARG-ST lists the syntactic arguments of their (lexical) verbal arguments in (55); see Godard & Samvelian (2024), Chapter 11 of this volume for details on approaches to complex predicates in HPSG.

$$(55) \quad \begin{bmatrix} \text{ARG-ST} & \left\langle ..., \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{ARG-ST} & \boxed{1} \end{bmatrix} \right\rangle \oplus \boxed{1} \end{bmatrix}$$

Finally, (negative) adverbs that select for a verb (VP) are added to the ARG-ST of the verb they select, as shown in (56). The symbol ◯ in this rule is known as "shuffle"; it represents any list in which the elements of the two lists are intermixed containing the combined elements of the two lists, but with the relative ordering of elements on each list preserved.[8]

$$(56) \quad \begin{bmatrix} \text{ARG-ST} & \boxed{1} \end{bmatrix} \mapsto \begin{bmatrix} \text{ARG-ST} & \boxed{1} \ \bigcirc \ \langle \text{ADV}_{neg} \rangle \end{bmatrix}$$

7 Is ARG-ST universal?

HPSG's ARG-ST attribute does not seem to be a universal property of natural language grammars. The ARG-ST feature is the intermediary between, on the one hand, a semantic representation of an event or state in which participants fill specific roles, and on the other, their syntactic and morphological expression. ARG-ST is defined as a list of *synsem* objects in the entry for a verb lexeme, and is used to model the following grammatical regularities of particular predicators or sets of predicators:

- The verb selects grammatical features such as part of speech category, case marking, and preposition forms of its dependent phrases.

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[8]See Müller (2024b: 414), Chapter 10 of this volume for more on the shuffle operator.

- ARG-ST list items:

    1. are identified with valence list items representing grammatical properties of phrasal dependents (subject and complements),

    2. determine verbal morphology, or

    3. are left unexpressed.

- The different contexts of occurrence of a verb correspond to distinct ARG-ST values.

- The inflected verb can indicate agreement features of any arguments, regardless of whether they are lexical, phrasal, or affixal.

- Binding conditions on arguments are defined on ARG-ST, making crucial use of the ordering relation (obliqueness).

Koenig & Michelson (2014, 2015a,b) argue that the grammatical encoding of semantic arguments in Oneida (Northern Iroquoian) does not display any of these properties. In fact, the only function of the corresponding intermediate representation in Oneida is to distinguish the arguments of a verb for the purpose of determining verbal prefixes indicating semantic person, number, and gender features of animate arguments. For example, the prefix *lak-* occurs if a third-person singular masculine proto-agent argument is acting on a first-person singular proto-patient argument as in *lak-hlo·lí-heʔ* 'he tells me' (habitual aspect), whereas the prefix *li-* occurs if a first singular proto-agent argument is acting on a third masculine singular argument, as in *li-hlo·lí-heʔ* 'I tell him' (habitual aspect). As there is no syntactic agreement, these verbal prefixes encode purely semantic features. *Synsem* objects are therefore not appropriate for this intermediate representation; all that is needed are semantic argument indices to distinguish between (a maximum of two) animate co-arguments distinguished for fixed argument roles for each verb. Koenig & Michelson use the attribute INFL-STR – a highly restricted Oneida feature that replaces ARG-ST – which is a list of referential indices for animate arguments within the inflectional information associated with each verb (see Crysmann 2024: Section 4, Chapter 21 of this volume for more details on current theories of inflectional morphology in HPSG). If Koenig & Michelson are correct, the ARG-ST list may thus not be a universal attribute of words, though present in the overwhelming majority of languages. Linking, understood as constraints between semantic roles and members of the ARG-ST list, is then but one possibility; constraints that relate semantic roles to an INFL-STR

list of semantic indices is also an option. In languages that exclusively exploit that latter possibility, syntax is indeed simpler.

8 The lexical approach to argument structure

We end this chapter with a necessarily brief comparison between the approach to argument structure we have described here and other approaches to argument structure that have developed since the 1990s. This chapter describes a *lexical approach to argument structure*, which is typical of research in HPSG. The basic tenet of such approaches is that lexical items include argument structures, which represent essential information about potential argument selection and expression, but abstract away from the actual local phrasal structure. In contrast, *phrasal approaches*, which are common both in Construction Grammar and in transformational approaches such as Distributed Morphology, reject such lexical argument structures. Let us briefly review the reasons for preferring a lexical approach. (This section is drawn from Müller & Wechsler 2014, which may be consulted for more detailed and extensive argumentation. See also Müller 2024c: Section 2, Chapter 32 of this volume.)

In phrasal approaches to argument structure, components of a verb's apparent meaning are actually "constructional meaning" contributed directly by the phrasal structure. The linking constraints of the sort discussed above are then said to arise from the interaction of the verb meaning with the constructional meaning. For example, agentive arguments tend to be realized as subjects, not objects, of transitive verbs. On the theory presented above, that generalization is captured by the linking constraint (16), which states that the ACTOR argument of an *act-und-rel* (actor-undergoer relation) is mapped to the initial item in the ARG-ST list. In a phrasal approach, the agentive semantics is directly associated with the subject position in the phrase structure. In transformational theories, a silent "light verb" (usually called "little *v*") heads a projection in the phrase structure and assigns the agent role to its specifier (the subject). In constructional theories, the phrase structure itself assigns the agent role. In either type of phrasal approach, the agentive component of the verb meaning is actually expressed by the phrasal structure into which the verb is inserted.

The lexicalist's approach to argument structure provides essential information for a verb's potential combination with argument phrases. If a given lexical entry could only combine with the particular set of phrases specified in a single valence feature, then the lexical and phrasal approaches would be difficult to distinguish: whatever information the lexicalist specifies for each valence list item

could, on the phrasal view, be specified instead for the phrases realizing those list items. But crucially, the verb need not immediately combine with its specified arguments. Alternatively, it can meet other fates: it can serve as the input to a lexical rule; it can combine first with a modifier in an adjunction structure; it can be coordinated with another word with the same predicate argument structure; instead of being realized locally, one or more of its arguments can be effectively transferred to another head's valence feature (raising or argument composition); or arguments can be saved for expression in some other syntactic position (partial fronting).[9] Here we consider two of these, lexical rules and coordination.

The lexically encoded argument structure is abstract: it does not directly encode the phrase structure or precedence relations between this verb and its arguments. This abstraction captures the commonality across different syntactic expressions of the arguments of a given root.

(57) a. The rabbits were nibbling the carrots.

  b. The carrots were being nibbled (by the rabbits).

  c. a large, partly nibbled, orange carrot

  d. the quiet, nibbling, old rabbits

  e. the rabbit's nibbling of the carrots

  f. The rabbit gave the carrot a nibble.

  g. The rabbit wants a nibble (on the carrot).

  h. The rabbit nibbled the carrot smooth.

Verbs undergo morpholexical operations like passive (57b), as well as antipassive, causative, and applicative in other languages. They have cognates in other parts of speech such as adjectives (57c, d) and nouns (57e, f, g). Verbs have been argued to form complex predicates with resultative secondary predicates (57h), and with serial verbs in other languages.

The same root lexical entry *nibble*, with the same meaning, appears in all of these contexts. The effects of lexical rules together with the rules of syntax dictate the proper argument expression in each context. For example, if we call the first two arguments in an ARG-ST list (such as the one in (57) above) Arg1 and Arg2 (or ACT or UND), respectively, then in an active transitive sentence Arg1 is the subject and Arg2 the object; in the passive, Arg2 is the subject and the referential index of Arg1 is optionally assigned to a *by*-phrase. The same rules of

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[9]See Müller 2024c: Section 2.2, Chapter 32 of this volume for discussion of partial verb phrase fronting.

syntax dictate the position of the subject, whether the verb is active or passive. When adjectives are derived from verbal participles, whether active (*a nibbling rabbit*) or passive (*a nibbled carrot*), the rule is that whichever role would have been expressed as the subject of the verb is assigned by the participial adjective to the referent of the noun that it modifies; see Bresnan (1982: 21–32) and Bresnan et al. (2016: Chapter 3). The phrasal approach, in which the agent role is assigned to the subject position, is too rigid.

This issue cannot be solved by associating each syntactic environment with a different meaningful phrasal construction: an active construction with agent role in the subject position, a passive construction with agent in the *by*-phrase position, etc. The problem for that view is that one lexical rule can feed another. In the example above, the output of the verbal passive rule (see (57b)) feeds the adjective formation rule (see (57c)).

A verb can also be coordinated with another verb with the same valence requirements. The two verbs then share their dependents. This causes problems for the phrasal view, especially when a given dependent receives different semantic roles from the two verbs. For example, in an influential phrasal analysis, Hale & Keyser (1993) derived denominal verbs like *to saddle* through noun incorporation out of a structure akin to [PUT a saddle ON x]. Verbs with this putative derivation routinely coordinate and share dependents with verbs of other types:

(58)   Realizing the dire results of such a capture and that he was the only one to prevent it, he quickly [saddled and mounted] his trusted horse and with a grim determination began a journey that would become legendary.[10]

Under the phrasal analysis, the two verbs place contradictory demands on a single phrase structure. But on the lexical analysis, this is simple V^0 coordination.[11]

To summarize, a lexical argument structure is an abstraction or generalization over various occurrences of a predicator in syntactic contexts. To be sure, one key use of that argument structure is simply to indicate what sort of words or phrases the predicator must (or can) combine with; if that were the whole story, then the phrasal theory would be viable. But it is not. As it turns out, lexically-encoded valence structure, once abstracted, can alternatively be used in other ways: among other possibilities, the predicator (crucially including its valence structure) can be coordinated with other predicators that have a similar valence

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[10]Example from "Jack Jouett House Historic Site: Jack Jouett's Ride"; http://jouetthouse.org/jack-jouetts-ride/, 19.03.2021

[11]See also Abeillé & Chaves (2024: Section 5), Chapter 16 of this volume on lexical coordination and for arguments why approaches assuming phrasal coordination for these cases fail.

structure, or it can serve as the input to lexical rules specifying a new word or lexeme bearing a systematic relation to the input word. The phrasal approach prematurely commits to a single phrasal position for the realization of a semantic argument. In contrast, a lexical argument structure gives a word the appropriate flexibility to account for the full range of expressions found in natural language.

Acknowledgments

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