2015).[8] From a diachronic perspective, one would either assume that infinitival as well as participial complements carry a feature GOVR which is underspecified in earlier stages of German (= GOVR *dir*) allowing for the attested variation of word orders, cf. figure 2, or one would go on the assumption that the head feature GOVR arises only later in the history of German. In the context of example (18b), the value of GOVR may be determined as follows: The participle *gesehen* 'seen' is governed by the auxiliary *worden* 'been' appearing on its right side and the GOVR value of the verb cluster *gesehen worden* is feature shared with its head daughter *worden* which is governed by the auxiliary *worden*.

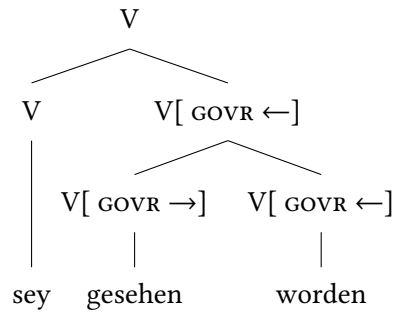


Figure 2: Three-place verb cluster in Early New High German

In Present-day German, a three-place verb cluster including the auxiliary *sein* 'be' exhibits the canonical word order $V_3V_2V_1$. In contrast to Early New High German, the feature value is provided by the lexical entry of the respective verb. A partial lexical description of the passive participle *worden* 'been' is illustrated below, indicating that its governing auxiliary has to appear on the right side.

(19) *worden*-AUX 'been':

$$\begin{bmatrix} \textsc{phon} \langle\ \textit{worden}\ \rangle \\ \textsc{synsem|loc|cat} \begin{bmatrix} \textsc{head} \begin{bmatrix} \textit{verb} & \\ \textsc{vform} & \textit{passive-part} \\ \textsc{aux} & + \\ \textsc{govr} & \rightarrow \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

As has been suggested in work on synchronic variation as regards verb cluster in German and Dutch, diachronic variation can be modeled in a straightforward

[8] The head feature suggested by Hinrichs & Nakazawa (1994) is FLIP which indicates government to the right when exhibiting a positive value as in example (17a) above.

way by building on lexical entries of verbs. The analysis of the word order change sketched above makes use of the possibility that a lexical feature may be underspecified in a particular variety of a language.

2.3 Left Periphery of Noun Phrases

The third case study presents a bundle of changes affecting the left periphery of noun phrases in the history of German. All changes might be due to a single change as regards the relationship between nominal and determiner (Demske 2001).

The historical record indicates that the distribution of adjectival inflection types is semantically governed in Old High German, i.e. definite determiners trigger weak adjectival inflection, whereas indefinite determiners call for strong adjectival inflection. In (20), the weak declension type is triggered by the demonstrative and the possessive determiner, respectively, while the strong declension type in (21) is motivated by the indefinite pronoun. In contrast to Present-day German the strong declension type is used irrespective of the morphology of the indefinite determiner (cf. *ein* vs. *einemo*). Old High German behaves in this respect as Modern Icelandic.[9]

(20) a. thiz irdisg-a dal (OHG)
this worldly-WEAK valley
'this worldly valley'

b. min liob-o sun (OHG)
my good-WEAK sun
'my good sun'

(21) a. ein arm-az uuîb (OHG)
a poor-STRONG woman
'a poor woman'

b. einemo diur-emo merigrioze (OHG)
a valuable-STRONG pearl
'a valuable pearl'

In Present-Day German the distribution of adjectival inflection types is morphologically governed: If grammatical features are overtly marked by the determiner,

[9] In Modern Icelandic, a definite noun phrase requires a weakly inflected adjective and an indefinite noun phrase a strongly inflected one: *þessi raud-i hestur* 'this red horse' vs. *raud-ur hestur* ' a red horse'.

the following adjective instantiates the weak inflection type, otherwise the adjective exhibits strong inflection (cf. *ein* vs. *einem*).

(22) a. ein herausragend-er Cellist (PDG)
an outstanding-STRONG cellist

b. einem herausragend-en Cellisten (PDG)
an outstanding-WEAK cellist
'an outstanding cellist'

The changing nature of the relationship between determiner and nominal may be captured by a change in the feature structure of the determiner: In Old High German, it is the CONTENT feature of the determiner that drives the distribution of adjectival declension types, in Present-day German on the other hand, the distribution is driven by its CAT feature. The feature description of the indefinite determiner Old High German includes as AGRfeatures CASE, NUMBER and GENDER[10]. The feature SPR indicates that the determiner requires a nominal expression lacking a specifier, i.e. NOM(Sag et al. 2003). The index [1] signals the structure sharing of the determiner's CONTENT feature with the DECLfeature of the nominal expression. Determiner and nominal agree in the following example with respect to indefiniteness.

(23)
$$\left[\begin{array}{l}\textsc{phon}\ \langle\ \textit{einemo}\ \rangle \\ \textsc{synsem|loc}\left[\begin{array}{l}\textsc{cat}\left[\begin{array}{ll}\textsc{head} & \left[\begin{array}{ll}\textit{det} & \\ \textsc{agr} & \left[\begin{array}{ll}\textsc{case} & \textit{dat}\\ \textsc{num} & \textit{sg}\\ \textsc{gend} & \textit{masc}\end{array}\right]\end{array}\right] \\ \textsc{spr} & \langle\ \textsc{nom}\ [\textsc{decl}\ \boxed{1}\ ]\ \rangle\end{array}\right] \\ \textsc{content}\left[\begin{array}{ll}\textsc{det} & \textit{exists}\\ \textsc{restind} & \boxed{1}\end{array}\right]\end{array}\right]\end{array}\right]$$

In Present-day German, the DECLvalue of NOMno longer conveys information about its definiteness. The determiner selects for NOMaccording to categorial features: In case the determiner provides information on the AGRvalue of the noun phrase, it asks for a weakly inflected NOMas in (24).[11] Otherwise the information

[10] Disregarding the context in (21), the determiner *einemo* may also agree with a neuter noun.

[11] In my view, DECLis not a HEAD feature of the determiner, since declension type is an inherent feature of determiners. Cf. however Kiss (1995: 72).

in question has to be provided by a strongly inflected NOM.[12]

(24)
$$\begin{bmatrix} \textsc{phon} \langle\ \textit{einem}\ \rangle \\ \textsc{synsem|loc|cat} \begin{bmatrix} \textsc{head} \begin{bmatrix} \textit{det} \\ \textsc{agr} \begin{bmatrix} \textsc{case} & \textit{dat} \\ \textsc{num} & \textit{sg} \\ \textsc{gend} & \textit{masc} \end{bmatrix} \end{bmatrix} \\ \textsc{spr} \quad \langle\ \textsc{nom}\ [\textsc{decl}\ \textit{weak}]\ \rangle \end{bmatrix} \end{bmatrix}$$

The changing nature of the relationship between determiner and NOMcan be modeled by modifying the feature structure of SPR in the lexical description of the determiner. A possible motivation for this change comes from the increasing grammaticalization of the definite determiner: While the determiner is attested above all with sortal concepts in Old High German testifying to its use as a demonstrative, it lacks in cases where the head noun refers to functional concepts that are inherently unambiguous (Demske 2001). The examples in (25) illustrate this distribution: A head noun like *figboum* 'figtree' has a sortal meaning, i.e. its unique referent is specified by the context in (25a), while the noun *erda* 'earth' denotes a functional concept which refers unambiguously irrespective of particular situations (25b). A demonstrative determiner as *ther* 'this one' is hence excluded in such a context.

(25) a. Inti quad Imo, niomer fon thir uuahsmo arboran uuerde zi éiuuidu thô sâr sliumo arthorr&a **ther figboum**. (OHG)
'and he saith unto it, Let there be no fruit from thee henceforward for ever. And immediately the fig tree withered away.'

b. Inti **erda** giruorit uuas Inti steina gislizane uuarun (OHG)
'And the earth shook and the rocks were split.'

The rise of weak definites in the course of Early New High German represents a further step in the grammaticalization process of the definite determiner: Relational nouns with their argument in postnominal position may lack any determiner (26a) or they exhibit either the indefinite or the definite determiner (26b, 26c). The third pattern is the default pattern in Present-Day German (Demske 2019).

[12] Pollard & Sag (1994: 373) point out that nouns like *Verwandter* 'relative' support the assumption that DECLis a feature not only of adjectives but also of nouns, because the declension class of these nouns is governed by the respective determiner.

(26) a. Vnd wie wol ich bin **sone eins konigs** (ENHG)
'And though I am the son of a king.'

b. Sie namen **einen Zahn eines Thiers** / welches so groß ist wie eine Ratte (ENHG)
'They took the tooth of an animal which was as big as a rat.'

c. ich verstunde gleich aus ihrem Diskurs (…) daß ihr Mann beim Senat wäre, und ohngezweifelte Hoffnung hätte, denselben Tag **die Stell eines Landvogts oder Landamtmanns** zu bekommen (ENHG)
'From her conversation I came to discover that her husband was in the senate (…) He was also supposed to have had good expectations of receiving the position of a district governor or a bailiff that very day.'

In Present-Day German, definite determiners are used with sortal, functional and relational nouns, cf. (27), suggesting that the definite determiner is no longer licensed on semantic grounds as in Old High German, but on morphological grounds. The changing distribution of the definite determiner fits nicely the assumption that the specifier relation originally is semantically based and then turns into a morphologically based relationship.

(27) a. Der Mond ist aufgegangen. (PDG)
'The moon has risen.'

b. Sie ist die Tochter eines Unternehmers. (PDG)
'She is the daughter of an entrepreneur'

The increasing grammaticalization of the nominal left periphery has further effects on pre-head constituents. The demonstrative pronoun *solch* 'such' has either a sortal or an individual reading in older stages of German allowing for singular count nouns to occur without another determiner (28). In Present-Day German, *solch* is restricted to a sortal interpretation and exhibits classical diagnostics for adjectivehood including the requirement of a determiner with singular count nouns (Demske 2005). The developing restrictions governing the use of the demonstrative pronoun *solch* 'such' are easily modeled within a lexical approach, going on the assumption that there are either two lexical entries for the demonstrative in earlier stages of German or that the HEAD feature allows both a SPR as well as a MOD relation between the demonstrative and the nominal head. With the development of the demonstrative *ther* 'this one' into the definite determiner, the demonstrative *solch* conventionalizes its use as a demonstrative adjective while losing the one as a determiner.

(28) derselbe Landherr hatt an jetzo **solche Türckin** / weil jhr man nicht zur hand / sondern verreist gewest / wider vnder die Türcken vmb etliche Türckische Teppich vnd andere sachen verkaufft / (ENHG)

'this overlord has sold now this Turkish woman to other Turkish people for several Turkish tapestry and other things, because her husband has been abroad.'

A significant role in the history of the left periphery is played by the adnominal genitive. Three stages have to be distinguished in its development: In the first stage, genitive noun phrases systematically appear in prenominal position as attested in OHG sources (29). The genitive is a prenominal complement at this stage indicated by the preceding determiner and adjective as illustrated by the second example. Note that the determiner and the adjective are marked for dative case as required by the initial preposition *in* 'in'.

(29) a. scouuot thes accares lilia uuvo sie uuahsen (OHG)
observe the field's lilies how they grow
'Observe how the lilies of the field grow.'

b. In dhemu heilegin daniheles chiscribe (OHG)
in the holy Daniel's scripture
'in the holy scripture of Daniel'

The adnominal genitive of stage two also occurs in prenominal position, provided that it denotes humans or animals, cf. (30). All adnominal genitives marked [-animate] are now limited to postnominal position as testified by historical data from the Early New High German period (Ebert 1988). The prenominal genitive is still a full noun phrase in stage two, allowing not only for pre-head, but also for post-head dependents as shown by the postnominal modifiers in (30), which can be phrasal or sentential.

(30) a. **Der Frawen zu vnseren zeiten** kunst weyßheit vnd tugende ist nit not zu erzelen (ENHG)

'The art, wisdom and virtue of women in our days does not need to be recounted'

b. Dieser Tagen seyn allhie **der Evangel**. **Fürsten vnnd Städt/ so zu Schwäbschen Hall jüngst beysamen gewest/** Abgesandte alher komen (ENHG)

'These days envoys of the Protestant sovereigns and cities have come here, after they have met at Schwäbisch Hall recently.'

The final stage in the development of the adnominal genitive is represented by Present-day German: The prenominal position is restricted to proper names and kinship terms disallowing any pre-head or post-head modifier. Genitive phrases headed by individual nouns appear in postnominal position irrespective of the feature [±animate].

(31) a. Selmas/Vaters altes Fahrrad
Selma's/Daddy's old bike

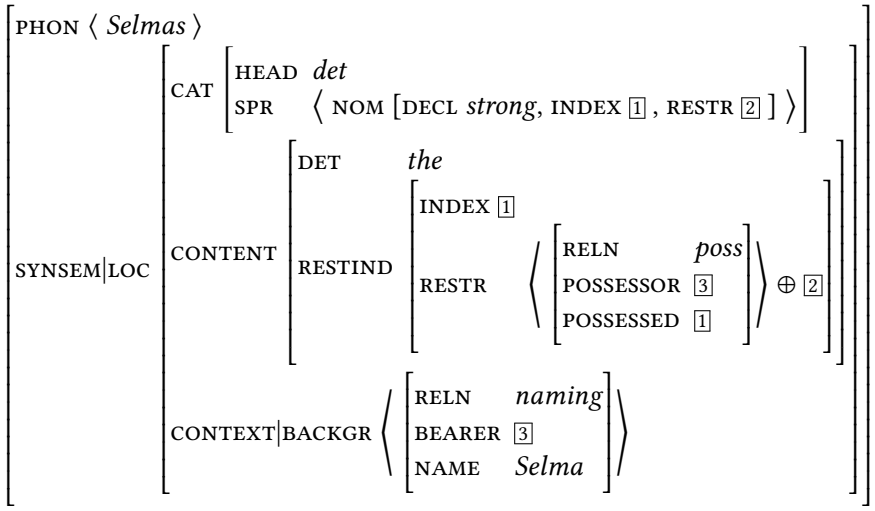
b. *der Menschheit ältester Traum
the mankind's oldest dream

(32) a. das Gartenhaus des alten Goethe
the summer house of the old Goethe

b. *des alten Goethe Gartenhaus
the old Goethe summer house
'the summer house of late Goethe'

The historical scenario sketched for the development of the adnominal genitive fits in well with other changes affecting the left periphery of noun phrases: While the adnominal genitive is a full noun phrase in Old High German functioning as a complement of the head noun, the adnominal genitive is used as a possessive determiner in Present-day German. Again the change can be modeled as a change affecting the relation between a prenominal constituent and the nominal head. The Old High German demonstrative pronouns *ther* 'this one' and *sulîh* 'such' conventionalize either an individual or a sortal reading in the history of German. Patterning with the former, the prenominal genitive conventionalizes a determiner relation to the nominal, provided that it can contribute a possessive meaning. Adnominal genitives with the feature [-animate] are consequently postponed and they retain their grammatical function as complements of the head noun. Prenominal genitives on the other hand become possessive determiners establishing a SPR relation to nominals with strong inflection (Pollard & Sag 1994: 54):

(33) Lexical item for *Selmas*:



The reanalysis of the relation between prenominal possessive and nominal in the history of German not only affects the pre-head genitive but also the possessive pronoun. In Middle High German and still in Early New High German, the possessive pronoun patterns with adjectives considering its co-occurrence patterns: It may follow a definite determiner and may even agree with another adjective as regards its declension type as in (34a). Here possessive pronoun and adjective both exhibit weak declension triggered by the preceding definite determiner. At this stage in the history of German, the possessive pronoun ist still a constituent of the nominal. The Early New High German example in (34b) shows that a possessive pronoun may also follow a prenominal adjective suggesting that it functions as a modifier itself (note also the agreement with respect to declencion type between adjective and possessive pronoun). This word order is excluded in Present-day German.

(34) a. die iuwer-n scoen-en tohter (MHG)
the your-WEAK beautiful-WEAK daughter
'your beautiful daughter'

b. mit gross-em jhr-em Rhum vnd Lob (ENHG)
with big-STRONG their-STRONG glory and praise
'with their big glory and praise'

Once again, it is the relation between prenominal element and head noun which is subject to change: The possessive pronoun behaves as an adjectival modifier in earlier stages of German, before it becomes a possessive determiner (i.e. MOD

relation develops into SPR relation). According to Pollard & Sag (1994: 54), its lexical description looks very much like the description of the prenominal genitive given above (disregarding the CONTENT and the CONTEXT value).

Changes at the left periphery of noun phrases start with the grammaticalization of the definite determiner throughout the period of Old High German, testified by a widening of its distribution. In Present-day German, not only sortal, but also functional and relational nouns combine with the definite determiner. The steady increase in the use of the determiner triggers a reanalysis of the relation between determiner and nominal: A semantically driven relation turns into a relation that is also morphologically based as evidenced by the changing trigger for the adjectival declension type. The determiner is consequently licensed by the CAT feature in the noun's feature structure as shown for the functional noun *Mond* 'moon' which subcategorizes for its determiner in Present-day German but has not done so in Old High German.

(35)
$$\left[\begin{array}{ll} \textsc{phon} & \langle\ \textit{Mond}\ \rangle \\ \textsc{synsem}|\textsc{loc}|\textsc{cat} & \left[\begin{array}{ll} \textsc{head} & \left[\begin{array}{l} \textit{noun} \\ \textsc{agr}\ \boxed{1} \end{array}\right] \\ \textsc{spr} & \left\langle \left[\textsc{head}\ \left[\begin{array}{l} \textit{det} \\ \textsc{agr}\ \boxed{1} \end{array}\right]\right] \right\rangle \\ \textsc{arg-st} & \langle\rangle \end{array}\right] \end{array}\right]$$

The reanalysis of the relation between determiner and nominal has consequences for the interpretation of other prenominal constituents: Possessive pronouns as well as possessor phrases are likewise taken to instantiate a specifier relation to the nominal in question, thus augmenting the class of determiners in German. In addition, pre-head constituents precluding a specifier interpretation are postponed, cf. genitive complements with [-animate], and pre-head constituents ambiguous between a specifier and a modifier reading are limited to one interpretation, cf. *solch* 'such' behaving as a demonstrative adjective in Present-day German. All changes can be modeled in a straightforward way as lexical changes.

3 Summary

Recent years witnessed a growing consensus that syntactic change is best accounted for in the lexicon of a language. The consensus holds across frameworks: Biberauer & Walkden (2015) highlight the role of the lexicon in Minimalism, the

volume by Butt & King (2001) exhibits case studies of syntactic change in the representational framework of LFG. The present contribution set out to show how the typed feature structures of HPSG can be used to model the way syntactic structures change over time. Different types of morpho-syntactic change have been considered in the history of German: the grammaticalization of auxiliary verbs and of demonstrative pronouns, word order changes affecting verb and noun phrases and changing relations between prenominal constituents and the respective nominal. In all cases, the change in question can be modeled in terms of feature structures in the lexicon of a language.

Abbreviations

Acknowledgements

Sources

Include a list the historical sources used in the paper?

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Chapter 26

Acquisition

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1 Introduction

Duis pulvinar lacus id gravida ornare. Phasellus eu mauris sed tortor maximus condimentum ultrices in leo. Donec non erat nec nulla ullamcorper ornare sed id ex. Integer risus mauris, aliquet vel aliquam sed, feugiat quis nisi. Suspendisse quis nunc a turpis porttitor mollis. In luctus nulla id nunc dapibus, id rhoncus lorem pretium. Nunc eget fringilla velit, semper commodo diam. Suspendisse odio odio, euismod ac ornare sed, tincidunt ac arcu. Pellentesque vitae fringilla orci. Donec faucibus metus dui, nec iaculis purus pellentesque sit amet. Sed fermentum lorem non augue cursus, eu accumsan risus ullamcorper. Suspendisse

Jonathan Ginzburg. N.d. Acquisition. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*. prepublished version. Berlin: Language Science Press. [Preliminary page numbering]

rhoncus magna vitae enim pellentesque, eget porttitor quam finibus. Nunc ultricies turpis at quam vehicula, at tempus justo molestie. Proin convallis augue ut turpis cursus rhoncus. Donec sed convallis justo. Sed sed massa pharetra ex aliquet eleifend. finality

Abbreviations

Acknowledgements

Chapter 27

Processing

Tom Wasow

Although not much psycholinguistic research has been carried out in the framework of HPSG, the architecture of the theory fits well with what is known about human language processing. This chapter enumerates aspects of this fit. It then discusses two phenomena, island constraints and relative clauses, in which the fit between experimental evidence on processing and HPSG analyses seems particularly good.

1 Introduction

Little psycholinguistic research has been guided by ideas from HPSG (but see Konieczny 1996 for a notable exception). This is not so much a reflection on HPSG as on the state of current knowledge of the relationship between language structure and the unconscious processes that underlie language production and comprehension. Other theories of grammar have likewise not figured prominently in theories of language processing, at least in recent decades.[1] The focus of this chapter, then, will be on how well the architecture of HPSG comports with available evidence about language production and comprehension.

My argument is much the same as that put forward by Sag et al. (2003: Chapter 9), and Sag & Wasow (2011; 2015), but with some additional observations about the relationship between competence and performance. I presuppose the "competence hypothesis" (see Chomsky 1965: Chapter 1), that is, that a theory of language use (performance) should incorporate a grammar representing the

[1]Half a century ago, the Derivational Theory of Complexity (DTC) was an attempt to use psycholinguistic experiments to test aspects of the grammatical theory that was dominant at the time. The DTC was discredited in the 1970s, and the theory it purported to support has longsince been superseded. See Fodor et al. (1974) for discussion.

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knowledge of language (competence) that is drawn on in everyday comprehension and production, as well as in other linguistic activities, such as language games and the (often artificial) tasks employed in psycholinguistic experiments.

The primary reason for adopting the competence hypothesis is parsimony: a theory of language use is simpler if it does not have to repeat much the same information about the language in both its production and comprehension components. This information would include things like the vocabulary, the preferred word orders, and most of the rest of what linguists encode in their grammars. A performance theory that incorporates a grammar only needs to include such information once.[2] Moreover, to the extent that the theoretical constructs of the grammar play a role in modeling both production and comprehension, the overall theory is simpler.

There is also, however, an empirical reason for preferring a model with a good fit between competence and performance. As noted by Bresnan et al. (2001), preferences that are only statistical tendencies in some languages can show up in others as categorical requirements. The example they discuss in detail is the avoidance of clauses with third-person subjects but first- or second-person objects or obliques. In English, this is a powerful statistical tendency, which they document by showing that the passivization rate in the Switchboard corpus is very significantly lower when the agent is first- or second-person than when it is third-person. In Lummi (a Salish language of British Columbia), this preference is categorical: clauses with third-person subjects but first- or second-person objects or obliques are simply unacceptable. Hawkins (2004; 2014) argues that such examples are by no means exceptional, and formulates the following "Performance-Grammar Correspondence Hypothesis" (PGCH):

> Grammars have conventionalized syntactic structures in proportion to their degree of preference in performance, as evidenced by frequency of use and

[2] There are of course some discrepancies between production and comprehension that need to be accounted for in a full theory of language use. For example, most people can understand some expressions that they never use, including such things as dialect-specific words or accents. But these discrepancies are on the margins of speakers' knowledge of their languages. The vast majority of the words and structures that speakers know are used in both production and comprehension. Further, it seems to be generally true that what speakers can produce is a proper subset of what they can comprehend. Hence, the discrepancies can plausibly be attributed to performance factors such as memory or motor habits. See Gollan et al. (2011) for evidence of differences between lexical access in production and comprehension. See Momma & Phillips (2018) for arguments that the structure-building mechanisms in production and comprehension are the same. For a thoughtful discussion of the relationship between production and comprehension, see MacDonald (2013) and the commentaries published with it.

ease of processing.[3]

There are two ways in which a processing model incorporating a grammar might capture this generalization. One is to give up the widespread assumption that grammars provide categorical descriptions, and that any quantitative generalizations must be extra-grammatical; see Francis (2019) for arguments supporting this option, and thoughful discussion of literature on how to differentiate processing effects from grammar. For example, some HPSG feature structures might allow multiple values for the same feature, but with probabilities (adding up to 1) attached to each value.[4] I hasten to add that fleshing out this idea into a full-fledged probabilistic version of HPSG would be a large undertaking, well beyond the scope of this chapter; see Linadarki (2006) and Miyao & Tsujii (2008) for work along these lines. But the idea is fairly straightforward, and would allow, for example, English to have *in its grammar* a non-categorical constraint against clauses with third-person subjects and first- or second-person objects or obliques.

The second way for a theory adopting the competence hypothesis to represent Hawkins's PGCH would be to allow certain generalizations to be stated either as grammatical constraints (when they are categorical) or as probabilistic performance constraints. This requires a fit between the grammar and the other components of the performance model that is close enough to permit what is essentially the same generalization to be expressed in the grammar or elsewhere. In the case discussed by Bresnan et al., for example, treating the constraint in question as part of the grammar of Lummi but a matter of performance in English would require that both the theory of grammar and models of production would include, minimally, the distinction between third-person and other persons, and the distinction between subjects and non-subjects. Since virtually all theories of grammar make these distinctions, this observation is not very useful in choosing among theories of grammar. I will return later to phenomena

[3] In the Bresnan et al. example, I know of no experimental evidence that clauses with third-person subjects and first- or second-person objects are difficult to process. But a plausible case can be made that the high salience of speaker and addressee makes the pronouns referring to them more accessible in both production and comprehension than expressions referring to other entities. In any event, clauses with first- or second-person subjects and third-person objects are far more frequent than clauses with the reverse pattern in languages where this has been checked. Thus, the Bresnan et al. example falls under the PGCH, at least with respect to "frequency of use" .

[4] I discussed this idea many times with the late Ivan Sag. He made it clear that he believed grammatical generalizations should be categorical. In part for that reason, this idea was not included in our joint publications on processing and HPSG.

that bear on the choice among grammatical theories, at least if one accepts the competence hypothesis.

Since its earliest days, HPSG research has been motivated in part by considerations of computational tractability (see Flickinger, Pollard & Wasow 2019, Chapter 2 of this volume, for discussion). Some of the design features of the theory can be traced back to the need to build a system that could run on the computers of the 1980s. Despite the obvious differences between human and machine information processing, some aspects of HPSG's architecture that were initially motivated on computational grounds have turned out to fit well with what is known about human language processing. A prime example of that is the computational analogue to the competence hypothesis, namely the fact that the same grammar is used for parsing and generation. In Section 3, I will discuss a number of other high-level design properties of HPSG, arguing that they fit well with what is known about human language processing, which I summarize in Section 2. In Section 4, I will briefly discuss two phenomena that have been the locus of much discussion about the relationship between grammar and processing, namely island constraints and differences between subject and object relative clauses.

2 Key facts about human language processing

In this section I review a number of well-known general properties of human language processing. Most of them seem evident from subjective experience of language use, but there is supporting experimental evidence for all of them.

2.1 Incrementality

Both language production and comprehension proceed incrementally, from the beginning to the end of an utterance. In the case of production, this is evident from the fact that utterances unfold over time. Moreover, speakers very often begin their utterances without having fully planned them out, as is evident from the prevalence of disfluencies. On the comprehension side, there is considerable evidence that listeners (and readers) begin analyzing input right away, without waiting for utterances to be complete. A grammatical framework that assigns structure and meaning to initial substrings of sentences will fit more naturally than one that doesn't into a processing model that exhibits this incrementality we see in human language use.

I hasten to add that there is also good evidence that both production and comprehension involve anticipation of later parts of sentences. While speakers may

not have their sentences fully planned before they begin speaking, some planning of downstream words must take place. This is perhaps most evident from instances of nouns exhibiting quirky cases determined by verbs that occur later in the clause. For example, objects of German *helfen*, 'help', take the dative case, rather than the default accusative for direct objects. But in a sentence like (1), the speaker must know that the verb will be one taking a dative object at the time the dative case article *dem* is uttered.

(1) Wir werden dem Kind bald helfen. (German)
we will the.DAT child soon help
'We will help the child soon.'

Likewise, in comprehension there is ample evidence that listeners and readers anticipate what is to come. This has been demonstrated using a variety experimental paradigms. Eye-tracking studies (see Tanenhaus, Spivey-Knowlton & Sedivy 1995, Altmann & Kamide 1999, Arnold et al. 2007, among many others) have shown that listeners use semantic information and world knowledge to predict what speakers will refer to next.

Thus, a theory of grammar that fits comfortably into a model of language use should provide representations of initial substrings of utterances that can be assigned (partial) meanings and be used in predicting later parts of those utterances.

2.2 Non-modularity

Psycholinguistic research over the past four decades has established that language processing involves integrating a wide range of types of information on an as-needed basis. That is, the various components of the language faculty interact throughout their operation. A model of language use should therefore *not* be modular, in the sense of Jerry Fodor's influential (1983b) book, *The Modularity of Mind*.[5]

[5]Much of the psycholinguistic research of the 1980s was devoted to exploring modularity – that is, the idea that the human linguistic faculty consists of a number of distinct "informationally encapsulated" modules. While Fodor's book was mostly devoted to arguing for modularity at a higher level, where the linguistic faculty was one module, many researchers at the time extended the idea to the internal organization of the linguistic faculty, positing largely autonomous mechanisms for phonology, syntax, semantics, and pragmatics, with the operations of each of these sub-modules unaffected by the operations of the others. The outcome of years of experimental studies on the linguistic modularity idea was that it was abandoned by most psycholinguists. For an early direct response to Fodor, see Marslen-Wilson & Tyler (1987).