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THE ROLE OF THE LANGUAGE PRODUCTION SYSTEM IN SHAPING GRAMMARS

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We argue for an extension of the proposal that grammars are in part shaped by processing systems. Hawkins (2014) and others who have advanced this idea focus primarily on parsing. Our extension focuses on production, and we use that to explore explanations for certain subject/object asymmetries in extraction structures. The phenomenon we examine, which we term the MIRROR ASYMMETRY, runs in opposite directions for within-clause and across-clause (long-distance) extraction, showing a preference for subject extraction in the former and for object extraction in the latter. We review several types of evidence suggesting that the mirror asymmetry and related phenomena are best explained by an account of the formation of grammars that assigns an important role to properties of sentence planning in production.*

Keywords: language evolution, performance-grammar correspondence hypothesis, linguistic ecosystem, language production, language acquisition, syntax, extraction, relative clause, mirror asymmetry

1. INTRODUCTION. We propose to account for certain crosslinguistic extraction phenomena by reference to features of the language production system. This has implications for the relation between a putatively universal competence grammar and the contributions of the processing systems that realize any such competence grammar in a specific language.

Recent research has challenged the conventional distinction between competence and performance in several ways. In some cases, phenomena attributed to the competence system are claimed to be performance effects. Chomsky (2008a) suggests this as a way to reconcile certain syntactic phenomena with the MINIMALIST PROGRAM, which posits MERGE as the sole syntactic operation. Hofmeister and Sag (2010) use empirical arguments to reach similar conclusions, holding that many WH-island phenomena reflect parsing rather than grammatical considerations. Hawkins (1994, 1999, 2004, 2010, 2014) and Newmeyer (2005) alter the competence/performance relationship more radically, suggesting that the processing systems can shape grammars. A language-particular grammar in such a framework might reflect a universal core grammar in a way that accommodates unique features of a particular LINGUISTIC ECOSYSTEM (especially its lexicon and morphophonological and morphosyntactic properties).¹ Any language must have some such ecosystem in order to be useable, but the creation of such a system en-

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¹ We use the term UNIVERSAL CORE GRAMMAR instead of UNIVERSAL GRAMMAR (UG) to distinguish this notion from the UG proposed in earlier frameworks (e.g. Chomsky 1981). The universal core might consist of Merge alone, as in minimalist proposals.

tails countless choices on points about which the core grammar is silent. These choices nevertheless have consequences for the practical problems that language users face in realizing the core grammar. Hawkins has proposed general parsing principles that he argues shape language-particular grammars such that the final product is the joint consequence of a linguistic ecosystem, the core grammar, and the parsing principles. By hypothesis, a language-particular grammar cannot be derived from any one of these sets of constraints alone; in particular, it cannot be deduced from the universal core grammar. A central observation supporting this line of investigation is that the same structures that are often impossible crosslinguistically, such as oblique relative clauses, are relatively difficult to parse even in languages that allow them.

Hawkins's account, however, emphasizes language comprehension. If language production is at least as challenging as comprehension is, then properties of the production system should also play a role in shaping language-particular grammars. The phenomenon we focus on involves extraction asymmetries that run in opposite directions for within-clause movement and movement over a clause boundary. Studies on comprehension and production, as well as crosslinguistic grammaticality data, indicate that subject extraction is preferred over object extraction for within-clause movement, whereas the preference is reversed when movement crosses a clause boundary.² This pattern, which we term the MIRROR ASYMMETRY, is not explained by Hawkins's parsing-oriented proposals. We argue that a model extending his approach to production can handle it. Our article contributes to Hawkins's framework in two ways. First, our argument that the mirror asymmetry is best handled as a processing-based phenomenon supports his fundamental claim that grammars are shaped by processors. Second, we emphasize the role of language production.

The article is organized as follows. We first review salient aspects of Hawkins's framework (§2), and then explore evidence for the mirror asymmetry with respect to language production as well as parsing, grammar, and typology (§3). In §4, we detail our account of the mirror asymmetry, and consider our account in light of crosslinguistic data in §5. We then compare production- and parsing-based accounts (§6) and, finally, briefly consider the implications of the overall proposal for the evolutionary architecture of the language faculty (§7).

2. THE PERFORMANCE-GRAMMAR CORRESPONDENCE HYPOTHESIS. Questions about how processing contributes to grammar have been discussed for decades (e.g. Bever 1970, Bever & Langendoen 1971, Fodor 1978, 1984, Langendoen 1970, Lightfoot 1999). Hawkins's account is the most developed, in that he has formulated several specific principles that handle crosslinguistic phenomena. His most fundamental principle is the PERFORMANCE-GRAMMAR CORRESPONDENCE HYPOTHESIS (PGCH), which is stated in 1.

- (1) PERFORMANCE-GRAMMAR CORRESPONDENCE HYPOTHESIS: Grammars have conventionalized syntactic structures in proportion to their degree of preference in performance, as evidenced by patterns of selection in corpora and by ease of processing in psycholinguistic experiments. (Hawkins 2004:3)

In addition to this fundamental principle, Hawkins proposes three efficiency principles that account for numerous crosslinguistic patterns: MINIMIZE DOMAINS (MiD), MINIMIZE FORMS (MiF), and MAXIMIZE ON-LINE PROCESSING (MaOP). The principles' ef-

² Comrie (1981) comments on this asymmetry, but does not offer an explanation. In his review of Comrie's book, Coopmans (1983) considers this asymmetry to challenge the validity of Comrie's typological generalizations.

fects can be broadly summarized as follows. MiD leads to a preference for dependency relations between elements that are identifiable within a small domain. Among other phenomena, this principle accounts for word-order preferences, such as heavy NP shift. With the lighter phrase first, a structure can be determined within a smaller domain. MiF leads to a preference for reduced/minimal units (phonemes, morphemes, words) over complex counterparts. The complex unit (such as a full DP instead of a pronoun) is reserved for cases where the form is unpredictable or low in frequency. MaOP leads to a preference for structures that the processor can deterministically analyze early in a linear sequence. Hawkins (2004:49) sums these principles up with the slogans ‘express the most with the least’ (MiD and MiF) and ‘express it earliest’ (MaOP).

Hawkins derived his principles primarily from findings on parsing. This approach is not uncommon; processing accounts of syntactic phenomena tend to be put in terms of parsing. That language production is rarely considered may reflect an imbalance between the amount of research on comprehension and the amount on production. This discrepancy is in turn due to the challenge of studying production experimentally, in particular, sentence formulation. But if the processing systems do shape grammars, then production is at least as likely to guide this process as comprehension.

Language production and language comprehension systems are intimately connected in their real-time interaction (e.g. monitoring of production by comprehension, predictive analysis of comprehension by production). A required foundation for such interaction and for successful communication is that these two systems share structures. The structures are in common, but the forces that affect sentence production are not the same as those that affect comprehension. Language production accounts describe the real-time integration of an utterance’s multiple parts in order to capture a speaker’s intended meaning. That system is driven by the conceptual content that is selected for expression (i.e. the intended message). Language comprehension is driven by the form of an utterance, and that data must lead to the target interpretation. Despite differences in data flow, the two systems converge on the same class of lexical and phrasal structures to which the compositional operations that determine meaning apply. Also, production processing is embedded in a contextually constrained discourse framework, and it can produce an utterance fitting that context. Comprehension processing must infer the conceptual content based on assumptions about the context and discourse framework plus the form of the utterance.

We assume that the production process includes both lexically driven syntactic generation and conceptually driven structural generation. (See Kempen & Hoenkamp 1987 and Levelt 1989 for discussion of the former, and Bock et al. 2004, Hwang & Kaiser 2014, and Konopka 2012 regarding the involvement of both processes.) A significant difference between production and comprehension is that the procedures (e.g. build NP) that the speaker can prepare may arise with a different time course from those that the listener must resort to. The speaker has firm knowledge of future message components at stages when the listener can only make guesses. Thus, a major difference between production and comprehension is the degree to which the production system can take account of, or be affected by, elements that occur late in the utterance. Once we have presented our production-based account of the mirror asymmetry, we compare it to a parsing-based account.

3. A CLOSER LOOK AT THE MIRROR ASYMMETRY. Both parsing-based accounts like Hawkins’s and non-processing-based accounts in generative grammar fail to capture the mirror asymmetry, stated in 2.

- (2) MIRROR ASYMMETRY: Within-clause subject extraction is preferred over within-clause object extraction, whereas the reverse preference occurs with extraction out of embedded clauses.

The following relative clause structures illustrate the mirror asymmetry.

- (3) Within-clause subject extraction: easy for parser, common crosslinguistically
There's the girl that ___ met you.
- (4) Within-clause object extraction: somewhat harder for parser, less common crosslinguistically
There's the girl that you met ___ .
- (5) Embedded subject extraction: crosslinguistically, often ungrammatical
a. There's the girl that I think that ___ met you.
b. There's the girl that I wonder when ___ met you.
- (6) Embedded object extraction: crosslinguistically, often not as bad as embedded subject extraction
a. There's the girl that I think that you met ___ .
b. There's the girl that I wonder when you met ___ .

The mirror asymmetry is mysterious from a parsing perspective, as Fodor (1984) pointed out. It is not surprising that within-clause subject extraction is preferred over within-clause object extraction, which various processing accounts explain, including Hawkins's. But why should this preference reverse in long-distance extraction? Although there is evidence that filler-gap relations that cross clause boundaries are more difficult for the parser (Frazier & Clifton 1989), this extra burden is shed early on in the subject cases. In a non-null-subject language like English, the parser should strongly prefer structures like 5, due to the immediate and unambiguous identifiability of the gap at the point of the tensed verb. There is no way for the verb (*met* in the examples above) to directly follow *that* or *when*, which means that an empty subject must intervene. The only possibility for these structures in English is the gap relating to the relative clause filler, which is the gap that the parser would have been searching for.³ The principles-and-parameters framework (Chomsky 1981) accounted for the embedded subject/object asymmetry with the EMPTY CATEGORY PRINCIPLE (ECP), but the reverse pattern in within-clause extraction was ignored (probably since it has been regarded as a preference in English rather than a difference in grammaticality).⁴

We turn now to our account's empirical underpinnings in language production as well as parsing, grammar, and typology. We consider the two parts of the mirror asymmetry in turn: the within-clause asymmetry (part 1) and the across-clause asymmetry (part 2).

3.1. PART 1 OF THE MIRROR ASYMMETRY. The contrast in the within-clause cases is well known (i.e. 3 and 4 above). The typological data are summed up by the KEENAN-COMRIE ACCESSIBILITY HIERARCHY (Keenan & Comrie 1977, 1979). The accessibility hierarchy represents a strong tendency for relative clause extraction possibilities to be organized as in 7.

³ Lightfoot (1999) and Newmeyer (2005) have suggested that the restriction on subject extraction is a dysfunctional by-product of the principle requiring lexical government of traces. That principle's origin is functional, facilitating the parser's search for traces. Whereas we agree that such a situation is possible, our account is preferable because it handles both parts of the mirror asymmetry uniformly.

⁴ The minimalist program offers several accounts of phenomena that were handled by the ECP, including Ishii 2004, Mayr 2008, Pesetsky & Torrego 2001, Roussou 2010, and Szczegielniak 1999. See also Kandybowicz 2006 for an account based on prosody.

(7) KEENAN-COMRIE ACCESSIBILITY HIERARCHY: subject > direct object > indirect object/oblique > genitive

In other words, if a language disallows extraction from a particular structure, it also disallows extraction from anything listed to the right of that structure in the hierarchy. Part 1 of the mirror asymmetry shows up as the first two structures on the hierarchy.

Although our focus is on structures with gaps, we also consider resumptive pronouns in terms of the mirror asymmetry. Importantly, the hierarchy for resumptive pronouns is the reverse of the Keenan-Comrie accessibility hierarchy. That is, languages that allow resumptive pronouns prefer them at lower positions on the hierarchy (Keenan & Comrie 1977, 1979).

We now turn to findings that reflect part 1 of the mirror asymmetry. Since the parsing data are well known (see summaries in Gutierrez-Mangado 2011, Hawkins 2004, and Kwon et al. 2010), we focus here on production. These data show the same preference for within-clause subject extraction over within-clause object extraction.

The preference for within-clause subject-gap relative clauses over within-clause object-gap relative clauses in production has been found in acquisition research in several languages (French: Labelle 1990; Spanish and English: Pérez-Leroux 1995; Polish: McDaniel & Lech 2003; English: McDaniel et al. 1998, McDaniel et al. 2010, McKee & McDaniel 2001, McKee et al. 1998) and in research on language disorders (Contemori & Garraffa 2010, Novogrodsky & Friedmann 2006, Zukowski 2009). Most of this work focuses on grammatical possibilities and explores participants' choice of or success with certain structures over others. We investigated sentence planning *per se* through the study of disfluencies (McDaniel et al. 2010). This approach allows for a more direct comparison of production difficulty across structures. In what follows, we consider two specific examples of the production data that demonstrate the subject/object asymmetry.

In various studies using a procedure designed to elicit subject and object relatives, children and adults produced within-clause subject-gap relative clauses at a higher rate than other structures. This pattern was especially striking in McDaniel et al. 1998. Children aged three to twelve (divided into young, middle, and older age groups) and adults produced almost exclusively subject relatives when subject relatives were targeted. But for object relative targets, each group other than the young children produced more subject than object relatives; even the young children produced subject relatives close to 50% of the time, as shown in Figure 1. It is noteworthy that the subject relatives produced in response to object targets are almost exclusively passive structures (e.g. *the boy that's being tickled by the elephant* for the target *the boy that the elephant is tickling*). Passives are infrequently produced in English, especially by young children (Ud Deen 2011).⁵

In the McDaniel et al. 2010 study of sentence planning, the comparative ease of subject over object showed up in overall fluency. This was expressed as a global difficulty score (DIFF) that summed a variety of disfluency markers (e.g. filled and unfilled pauses, restarts) across each utterance; scores were transformed to ratios to compensate for differences in utterance lengths. A high DIFF score indicated a relative lack of fluency. DIFF scores ranged between 0 and 2.5. Examples of the target sentences are given in 8. The children's mean DIFF score was 0.16 for subject extraction structures and 0.23 for object extraction structures (participants: thirty-six three- to eight-year-olds; num-

⁵ Labelle (1990) (French) and Pérez-Leroux (1995) (Spanish) found children using resumptive pronouns instead of gaps in object (and oblique) relative clauses, another indication of the comparative difficulty of object-gap structures.

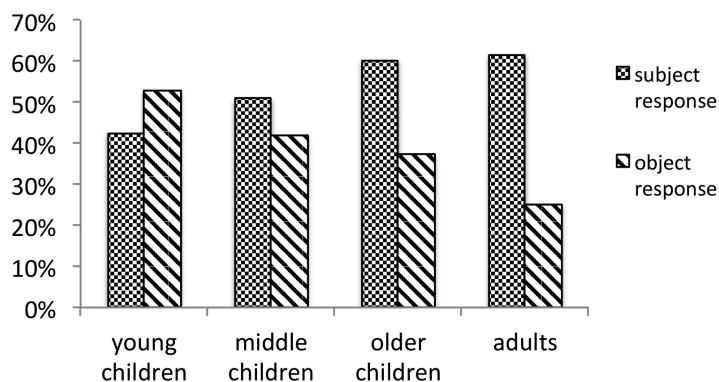


FIGURE 1. Percentage of subject and object relatives produced in response to object targets by each of three child age groups and an adult group in the McDaniel et al. 1998 elicited production study (total number of participants/utterances for each group = 36/108, 53/159, 26/78, 20/60).

ber of utterances per type: three; number of utterances of each type: 108; $t(35) = 2.967$, $p < 0.01$).

- (8) a. Within-clause subject
Pick up the baby that ___ is pulling the hen.
b. Within-clause object
Pick up the sheep that the doctor is rubbing ___ .

Before turning to part 2 of the mirror asymmetry, we consider nonstructural accounts of the subject/object asymmetry in within-clause extraction. Specifically, several studies have shown that animacy and thematic-role relationships affect subject/object relative clause preferences in both production and comprehension (e.g. Betancort et al. 2009, Branigan et al. 2008, Gennari & MacDonald 2009, MacDonald 2013, Mak et al. 2002). These raise the question of whether the subject/object asymmetry in relative clauses can be attributed to animacy. MacDonald (2013), for example, presents cross-linguistic data showing that object relatives are readily produced when the head of the relative clause is inanimate and the subject is animate, and that the passive (subject relative) form is otherwise preferred. This suggests that the preference for subject relatives derives from an animacy effect (which she in turn attributes to fundamental production biases). Although the McDaniel et al. 2010 study was not designed to explore animacy, the data bear on this question. All of the items were like those in 8, with two animate participants. If the subject/object asymmetry were derived from animacy effects, then the DIFF scores should not distinguish these cases.⁶ We do not claim that animacy plays no role in the subject/object asymmetry, but rather that it cannot be the whole story. There are undoubtedly animacy and thematic-role effects, but the structural preference also exists independently. Our account focuses on the structural difference.

3.2. PART 2 OF THE MIRROR ASYMMETRY. We now turn to the reverse subject/object asymmetry in extraction out of an embedded clause. As in the case of part 1 of the mir-

⁶ One of the items in McDaniel et al. 1998 also provides a striking counterexample to MacDonald's generalization. The target was *The plane that the dog is barking at*. This contains a relative clause with an inanimate head, an animate subject, and the gap as the object of a preposition. (This item is not included in Fig. 1, since the gap in the target structure was not the object of a verb.) Approximately one third of the responses in every age group used the passive structure, *The plane that is being barked at (by the dog)*. Here, participants appear to be driven by a subject-gap preference, in spite of the animacy relations and the complexity of the passive structure with the preposition.

ror asymmetry, we discuss various types of evidence for this. Since long-distance extraction is rarely reported in typological studies, the typological evidence is fragile. According to Comrie (1981:155), there is ‘good cross-linguistic evidence for [this] surprising generalization’, but he only gives a few examples. In any case, the typological data we have is clearly suggestive.

Languages differ in the extent to which they permit any extraction out of embedded clauses. Hawkins (2004:194) summarizes the typological data in terms of the hierarchy stated in 9. For purposes of exposition, we conflate the last two structures in his hierarchy (complex NP and WH-islands) under the label SUBJACENCY STRUCTURES.

- (9) CLAUSE-EMBEDDING HIERARCHY FOR GAPS: infinitival complement > finite complement > subjacency structures

Where part 2 of the mirror asymmetry pattern holds, it means that subject extraction is less preferred than object extraction, especially at the lower positions on this hierarchy (as extraction generally becomes harder). Evidence from a variety of sources supports this.

With respect to subjacency structures, the subject/object asymmetry is exemplified in 5b and 6b above, repeated here.

- (5) b. There’s the girl that I wonder when __ met you.

- (6) b. There’s the girl that I wonder when you met __ .

McDaniel & Cowart 1999 showed the effect experimentally. Participants judged sentences like 5b significantly less acceptable than sentences like 6b (-0.52 vs. -0.33 , $t_1 = 4.04$, $p < 0.001$, $N = 36$).

Arguing that subjacency phenomena are parsing effects, Hofmeister and Sag (2010) placed English (and possibly human language generally) further rightward on the hierarchy than has previously been claimed. According to these scholars, then, extraction out of subjacency structures is grammatical.⁷ Importantly, they explicitly limited their discussion to complex NP and WH-island structures with extraction of complements and adjuncts, and contended that other island phenomena could originate from actual syntactic constraints. Subject extraction out of subjacency structures seems to fall under this category (the latter historically treated as violations of the ECP in addition to subjacency).

Another place to look for the embedded subject/object asymmetry is in languages that are standardly claimed to be at the rightward end of the continuum, such as the Scandinavian languages, which allow extraction out of various types of subjacency structures. Although some of these languages allow subject extraction in some cases, it is more restricted than object extraction (Engdahl 1985, 1997). For example, Engdahl (1997) reports that Swedish allows topicalization of the object out of a relative clause, but not of the subject, as illustrated by the following examples (her 14a and 12).

- (10) a. Object extraction (topicalization) out of relative clause

Den teorin känner jag ingen [som tror på __].
that theory know I nobody that believes in

- b. Subject extraction (topicalization) out of relative clause

*Den här lingvisten finns det ingen teori [som __ tror på].
that linguist there.is.no theory that believes in

We now turn to data on structures with embedded complement clauses. Comrie (1981:155) gives examples from Hungarian and Imbabura Quechua indicating that the

⁷ See Sprouse et al. 2012a for the view that subjacency effects must be accounted for by grammatical theory or by a grounded theory (one that proposes grammaticalization based on processing pressures, as in our account), but not by real-time parsing processes. See also Hofmeister et al. 2012 and Sprouse et al. 2012b for further discussion.

subject of a complement clause cannot be relativized, whereas the object can. Evidence for part 2 of the mirror asymmetry can also be found in the passives in McDaniel et al. 2010. Recall that even young children used the passive when producing within-clause object extraction targets as subject relatives. For relative clause targets with embedded object extraction, passives almost disappear, as shown in Table 1.

	WITHIN-CLAUSE EXTRACTION	ACROSS-CLAUSE EXTRACTION
CHILDREN	12% ($N = 129$)	6% ($N = 119$)
ADULTS	23% ($N = 89$)	4% ($N = 86$)

TABLE 1. Percentage of passive (subject) relative clauses produced for object relative clause targets for within-clause and across-clause extraction by children aged three to eight and adults in the McDaniel et al. 2010 elicited production study (number of participants: forty-seven children, thirty adults; N s = number of utterances). Fisher's exact test, one tail: adults, $p < 0.0001$; children, $p < 0.085$.

Further evidence for part 2 of the mirror asymmetry is the *that*-trace effect. This effect is illustrated in the following examples, showing that subject extraction is ruled out with an overt complementizer in English.

- (11) a. There's the girl who I think you met __ .
 b. There's the girl who I think __ met you.
 c. There's the girl who I think that you met __ . [= 6a]
 d. *There's the girl who I think that __ met you. [= 5a]

Consider first the cases without *that* in 11a–b. Exploring this subject/object contrast in a comprehension study, Pickering and Shillcock (1992) found that the subject/object asymmetry is the same for within-clause and across-clause structures; that is, structures like 11b, with subject extraction, are easier to parse than structures like 11a, with object extraction. This means that the mirror asymmetry does not hold in this case; the asymmetry is in the same direction for within-clause and across-clause extraction.

Consider now the structures with *that* in 11c–d, which do show the mirror asymmetry. Experimental work on the *that*-trace effect in English (e.g. Cowart 1997) indicates that it is more complex than usually reported, and in a way that is germane to our focus. First, it has been claimed that in some dialects of English, 11d is as good as the other three structures; in other words, there is no *that*-trace effect in some dialects (Sobin 1987). Cowart conducted grammaticality-judgment experiments in various regions around the US, including the Midwest, a region where speakers lacking the effect are said to be common. Every region that he investigated showed a robust *that*-trace effect. One way to reconcile the apparent contradiction is to assume that reports on differences in grammaticality are correct but that the structure is more difficult for the processing systems. In this way, the *that*-trace structure would be parallel to the cases that motivate Hawkins's account, where a structure is impossible in some languages, and possible but difficult in others.

Cowart's research revealed a second phenomenon that is rarely considered in accounts of the *that*-trace effect. Although not directly related to the mirror asymmetry, we present it here both because it is a problem for accounts of the *that*-trace effect, and because it plays a central role in part of our proposal. Cowart's *that*-trace experiments showed that the overt complementizer *that* reduced acceptability ratings in the object extraction structure in 11c, as well as in the subject extraction structure in 11d. In other words, both subject and object extraction with *that* are degraded, with the subject cases worse than the object cases. The pattern is shown in Figure 2 (Cowart 1997).⁸

⁸ A subsequent experiment using a larger sample corroborated the presence of a *that*-trace effect with object extraction (Cowart 1997:24–27 and appendix D). A referee suggested that this finding might reflect cer-

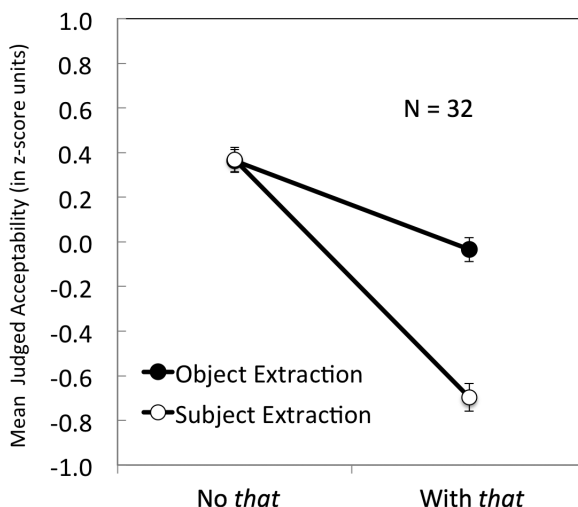


FIGURE 2. *That*-trace effect (data from Cowart 1997:19, figure 4).

This suggests that extraction out of a *that*-clause is difficult, independent of the extraction site.

The adult participants in McDaniel et al. 2010 showed the same pattern: they avoided *that* in both subject and object structures, and showed a slight subject/object asymmetry. The child data is interestingly different from the adult data. Children used the complementizer *that* approximately a third of the time in both subject and object structures. Table 2 shows the child and adult data from this study.

	SUBJECT	OBJECT
CHILDREN	38% ($N = 103$)	33% ($N = 117$)
ADULTS	4% ($N = 81$)	8% ($N = 86$)

TABLE 2. Percentage of utterances with *that* in subject and object across-clause extraction structures by children aged three to eight and adults in the McDaniel et al. 2010 elicited production study (number of participants: forty-seven children, thirty adults; N s = number of utterances).

An additional phenomenon relating to the *that*-trace effect is that, in English, the subject extraction structure with *that* becomes grammatical when the clause begins with a sentential adverbial. Culicover (1993) presents these cases as a problem for the ECP account of the *that*-trace effect. An example is given in 12 (his 2b).

(12) This is the tree that I said that **just yesterday** resisted my shovel.

In 13, we list the phenomena relating to the *that*-trace effect that we need to account for.

tain verbs' preferences (independently of the presence of extraction) for a null complementizer (Garnsey et al. 1997, Trueswell et al. 1993). But the Garnsey et al. sentence-completion study included seven of Cowart's verbs. These seven had an average *that*-preference score (percentage of time a completion with a tensed clause included *that*) of 64%. We also conducted a small sentence-completion study with Cowart's full set of verbs. Overall, the complementizer *that* was used in 67% of the completions with tensed clauses. The *that*-preference scores ranged from 33% to 100%, with only three verbs below 60%. (Number of subjects: sixteen; number of completions with tensed clauses: 183.) Cowart's findings therefore seem to reflect the extraction structure rather than the verbs' complementizer preference.

- (13) a. usual subject/object asymmetry in extraction out of complement clauses without *that* (do not exhibit the mirror asymmetry)
 b. *that*-trace effect (a subcase of the mirror asymmetry)
 c. difficulty of extraction out of all *that* clauses
 d. different patterns in children and adults
 e. lack of *that*-trace effect with initial sentential adverbial

The account we propose in §4 addresses the patterns that relate specifically to the *that*-trace phenomenon, as well as the mirror asymmetry in general.

Finally, we consider resumptive pronouns with respect to part 2 of the mirror asymmetry. Recall that, in within-clause extraction, the direction of the resumptive pronoun hierarchy is the opposite of the one for gaps, making subject resumptives less preferred than object resumptives. If the mirror asymmetry pattern holds, then object resumptives should be less preferred than subject resumptives in across-clause extraction structures. There is some evidence for this. First, though it is common for languages that otherwise use resumptive pronouns to disallow them in the highest subject position, this restriction does not extend to the embedded subject position (Sells 1984). Second, Swedish shows a subject-over-object resumptive pronoun preference in across-clause extraction structures. According to Engdahl (1985), resumptives do not improve island violations in Swedish (and, in fact, make them worse), except for the case of subject extraction, where the resumptive pronoun is grammatical. Similarly, the experimental investigation in McDaniel & Cowart 1999 suggested that resumptives improve only subject extraction structures, but not object extraction structures, in island violations in English, as shown in Figure 3.

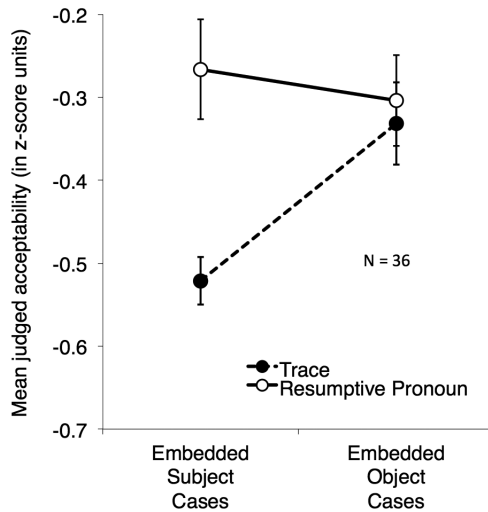


FIGURE 3. The relative acceptability of gapped vs. resumptive pronoun forms in embedded subject and embedded object structures (cf. 5 and 6, respectively). Data from McDaniel & Cowart 1999:B21, figure 1 (and see pp. B19–B22 for details of the procedure and results).

4. A PRODUCTION-BASED ACCOUNT. We reviewed data above that show the mirror asymmetry in grammar and processing, and in adults and children. We show here how the mirror asymmetry results from features of the production system. We state the account informally and then formalize it in terms of principles relating to language production.

Why would the speaker find it easier to produce within-clause subject extraction than within-clause object extraction structures, but find subject extraction harder than object

extraction in certain complex structures (complement clauses with an overt complementizer and subadjacency structures)? Informally, we suggest that the speaker finds it easiest to plan for a gap that is close to its filler; where the filler and gap are adjacent is the easiest. The picture changes, however, if extraction is out of an embedded clause and the subordinate clause is a separate planning unit. We argue that when the embedded clause is not well connected to the higher clause (a concept we discuss in detail below), the clauses are planned separately. A gap, though phonetically null, now creates a major planning challenge, since it relates syntactically to an element in a different planning unit. Beginning a planning unit with a complex structure is hard, since there may be insufficient time to plan it. It is easier to postpone the difficulty. For this reason, starting with a subject gap in an embedded clause is harder than planning for an object gap in an embedded clause.

An account along these lines relies on several properties of the production planning system. We specify these in turn, and then formalize our proposal. See also MacDonald 2013; the production biases that she proposes there have some elements in common with the production properties that we discuss below.

4.1. PROPERTIES OF THE PRODUCTION SYSTEM. Our account relies on the five properties listed in 14. We discuss each in turn in the subsections below.

(14) Properties of sentence planning in production

- a. The clause is a major planning unit.
- b. A salient antecedent facilitates the construction of a dependency relation.
- c. Overt material is minimized.
- d. Choice of clause type reflects degree of advance planning.
- e. Phrases are presented in order of increasing weight (PRINCIPLE OF END WEIGHT).

PROPERTY 1: THE CLAUSE IS A MAJOR PLANNING UNIT. One premise of our account is that the clause is a major unit in sentence planning, as in parsing. There is ample evidence for this in the production literature. Numerous studies on children and adults report pauses clustering at the onset of clauses (Beattie 1980, Boomer 1965, Butterworth 1980a, Clark & Wasow 1998, Ford & Holmes 1978, McDaniel et al. 2010). We focus on clausal processes at early stages of production; other units will, of course, be relevant in the overall process. Sentence planning is multilevel and concurrent in interesting respects. We think that clauses matter early on, while the detailed elaboration of lexical and phrasal units matters later. (See Konopka 2012 for discussion of variation in the size of the planning window.) Note that we also assume that planning is incremental. Presumably clause $X + 1$ is planned during the production of clause X . (See Ferreira & Slevc 2007 for more discussion of incremental planning.)

PROPERTY 2: A SALIENT ANTECEDENT FACILITATES THE CONSTRUCTION OF A DEPENDENCY RELATION. We assume it is easiest for speakers to construct a dependency relation where the antecedent is salient, meaning that it plays a prominent role in the sentence plan and is readily accessible. The salience of the filler in a relative clause structure is not due to inherent properties of the filler or to the speaker's emphasis on a certain part of the message (Osgood & Bock 1977). Rather, salience in this case is structurally driven; the onset of the relative clause structure itself establishes the salience of the filler.⁹

⁹ This notion of structurally guided salience echoes the proposal of Kuchinsky and colleagues (2011), who discuss the role of structure in the determination of lexical content for visual scene description. Selection of relevant content reflects the unfolding demands of the linguistic schema that is being implemented for scene description.

We suggest that, in most cases, the preference for a salient filler shows up as a preference for locality. This has been put in terms of parsing in accounts like Hawkins's, since local relationships are easier for the listener to identify. Unlike the listener, however, the speaker does not need to figure out dependency relationships; the speaker knows, for example, the antecedent of an anaphor and the thematic role of a gap corresponding to a filler. The challenge for the speaker is to plan the dependency *per se*, which involves having the filler in mind at the point where the gap is planned. Salience for the speaker will reflect the selection of conceptual material needed for sentence formulation. The filler will be most salient at the onset of the relative clause. That salience will make its greatest contribution to processing for early association of gap and filler, since salience declines over the course of planning the ensuing structure.¹⁰

PROPERTY 3: OVERT MATERIAL IS MINIMIZED. Speakers favor economy. They avoid introducing overt material where they can. This echoes Hawkins's slogan 'express the most with the least' and other proposals as well. For example, Levinson (2000) argues that a processing bottleneck (based on temporal limitations for phonological encoding) leads to communication systems that are designed to express more using fewer words. Fedzechkina and colleagues (2012), using an artificial language learning task, demonstrated a bias toward communicative efficiency; that is, the preference is for systems that successfully transfer information with a minimum of resource demands on the part of the speaker. Such considerations explain why a null element is preferred over an overt counterpart and, in particular, why gaps are generally preferred over resumptive pronouns.

PROPERTY 4: CHOICE OF CLAUSE TYPE REFLECTS DEGREE OF ADVANCE PLANNING. This property relates to property 1 (the clause is a major planning unit). Although clause-by-clause planning is the default approach to planning, we propose that the speaker may, under certain circumstances, plan the content of an embedded clause and the superordinate material as one unit. Such planning would occur in a situation where the speaker conceives of the material as highly connected. Degree of connectedness would depend on the local pragmatics, as well as semantic relations among concepts. A filler-gap structure would most naturally result from a message where the filler and gap parts are conceptually connected, since the speaker considers them as a unit. Such distinctions are particularly relevant for production processing accounts because of the capacity that speakers have for taking account of the nature of relations between early- and late-appearing elements of the target utterance.

Various frameworks appeal to some notion of connectedness between clauses. Generative analyses have included CP deletion or IP (rather than CP) complements, VP (rather than clausal) complements, and small clauses, as well as special relationships between the higher clause and certain types of embedded complements (control, bridge verbs, etc.). In the typology literature, a notion of connectedness is a factor in a larger continuum of clause-combining constructions that derive from parataxis (Givón 2009, Hopper & Traugott 1993).

Clausal connectedness is associated with several structural factors. One is inflectional material. The more connected a complement clause is to its superordinate clause,

¹⁰ The decrease in salience of the filler over the course of planning may also relate to MacDonald's (2013) REDUCE INTERFERENCE bias. This bias attributes the subject/object-gap asymmetry to interference of the intervening subject NP. Reduce interference explains why similarity between the subject NP and the filler increases the difficulty of the object-gap structure. Parsing accounts along these lines have been proposed as well (Friedmann et al. 2009, Rizzi 2013).

the less overt inflectional material it tends to contain. Rohdenburg (1996) states this relationship in terms of cognitive complexity.

- (15) COMPLEXITY PRINCIPLE: In the case of more or less explicit grammatical options, the more explicit one(s) will tend to be favored in cognitively more complex environments. (Rohdenburg 1996:151)

The degree of the embedded clause's connectedness with the superordinate clause corresponds to Hawkins's clause-embedding hierarchy: a more connected clause is easier to extract from. For our account, it is necessary to distinguish between complement clauses with and without the complementizer *that*. Rohdenburg uses several corpus studies for this distinction in terms of his notion of complexity. The differences that he discusses in usage between complement clauses with and without *that* are listed in 16.

- (16) The complementizer *that* is preferred in the following cases:
- when the superordinate verb is more formal and in more formal registers,
 - when material occurs between the superordinate verb and the complement clause (regardless of whether the material introduces a potential ambiguity),
 - when the superordinate clause is passive,
 - when the superordinate verb has a complex NP object in addition to the clausal object,
 - when the subordinate subject is complex,
 - when the subordinate clause is negated,
 - and/or when the subordinate clause is long.

Based on these distributional findings, Rohdenburg suggested that a fundamental factor in the use of *that* is clausal connectedness.¹¹

Using a sentence-recall task, Ferreira and Dell (2000) focused on *that* in gapless clausal complements. They manipulated the availability of the material of the embedded clause. In findings that match Rohdenburg's corpus-based findings, they reported that speakers used *that* when the material was less available. In one experiment, speakers were prompted with words that came from either the upper clause or the embedded clause. When the prompt consisted of embedded clause material, they used *that* less. In another experiment, the availability distinction lay in whether the pronominal subjects of the upper and lower clauses were the same or different. Speakers used *that* less when the subjects were the same. Ferreira and Dell proposed that the sentence formulator chooses a certain kind of clause (in this case, a tensed complement with or without *that*) depending on availability. They suggested that availability facilitates planning of the lower-clause material.

Our property 4 combines Ferreira and Dell's proposal with Rohdenburg's. In other words, the option of syntactically reduced structures with fewer functional elements is a way to plan two clauses as one chunk. In cases where the language provides a choice between the reduced structure and the full one (such as a complement clause with or without *that* in English), speakers generally use the reduced option when they perceive the content of the two clauses as closely connected. Filler-gap structures that cross a clause boundary tend to occur in the reduced structures crosslinguistically, since the

¹¹ Bolinger (1972) discussed the complementizer *that* in a variety of constructions. Elsness (1984), whose study of the Brown corpus was included in Rohdenburg 1996, also accounted for some findings along these lines. Thompson and Mulac (1991), who offered a pragmatic account of the distribution of *that*, also appealed to a notion of clausal connectedness, which they characterized as reanalysis of the superordinate and subordinate clauses as a unitary epistemic phrase.

conception of the filler-gap relationship imposes a connection between the content of the two clauses.

Note that this account of the complementizer differs from accounts where its use is attributed to a choice on the part of the speaker. Race and MacDonald (2003), for example, suggest that speakers use the optional relativizer *that* as a stalling device when they are having difficulty planning the next part. Jaeger (2005) argues, based on patterns of disfluencies, that the speaker instead uses this element to signal upcoming difficulties to the listener. In our account, at least in the case of the optional complementizer, its use is a SYMPTOM of an aspect of the planning process, indicating whether the clauses were planned together. If the clauses were planned separately, it is more likely that the speaker will return to the message level at the onset of the embedded clause. It is therefore not surprising that the use of *that* would correlate with a higher occurrence of disfluencies in the part that follows. Since the overt element occurs, it is a possible locus of stalling and it also signals to the listener that the upcoming part might be problematic (since it was not planned as far in advance). In fact, either or both of these factors may explain why it is that many languages have overt initial complementizers.

PROPERTY 5: THE PRINCIPLE OF END WEIGHT. There is ample evidence, in both the linguistic and psycholinguistic literature, for ordering preferences that generally result in lighter material preceding heavier material. Wasow (2002) discussed this at length, focusing on postverbal structures like heavy NP shift. He adopted the term used in Quirk et al. 1972:14.8: the PRINCIPLE OF END WEIGHT (PEW), defined as in 17.

(17) PRINCIPLE OF END WEIGHT: Phrases are presented in order of increasing weight. (Wasow 2002:3)

Wasow's experimental evidence suggested that the PEW derives from a sentence-planning preference rather than from a parsing preference. He characterized the PEW as a principle allowing the production system to buy time for the planning of more complex material. (See De Smedt 1994 for an earlier production-based account of the PEW.)

At first, it appears that the PEW makes the wrong prediction for us. It would seem that starting a clause with a subject gap should be particularly easy, since gaps are lighter than other material. But the PEW is about syntactic/semantic complexity rather than phonological weight. In most cases, phonological complexity covaries with syntactic complexity, since a category with more nodes will contain more words. Gaps, by contrast, tease apart these two notions of complexity. Phonologically, gaps could not be any lighter. But syntactically, they are highly complex, since they are dependent on another element, which may be clauses away. Starting an embedded clause with a gap therefore taxes the sentence-planning system. Note that the PEW makes opposite predictions about subject pronouns and subject gaps. Pronouns are both short and syntactically independent of other material. They are, therefore, both phonologically light and syntactically simple, and are predicted to be highly preferred as clause starters.¹²

4.2. APPLICATION TO EVIDENCE. We now show how the data we presented earlier can be accounted for by properties 1–5. We start with the more complex structures (part 2 of the mirror asymmetry), since a complication arises concerning the simpler cases (part 1 of the mirror asymmetry).

¹² Here we treat the PEW as a fundamental property of the production system. But it might derive from a more general property, such as some notion of salience, as discussed above (Osgood & Bock 1977). In this way, our properties 2 and 5 might be merged, but without a clearer sense of the principles that would underlie them, we keep them distinct for now.

EXTRACTION OUT OF SUBJACENCY STRUCTURES. This is the prime example of the clash between clause-by-clause planning and the filler-gap relationship. The complexity of the subjacency structures (which involve either adjuncts, which are relatively unconnected to the superordinate clause, or complement clauses containing a second filler-gap relationship) challenges joint planning of two clauses. Clause-by-clause planning is challenging as well, since the clause with the gap has to be planned without the filler. Any gap will be difficult, but a subject gap will be especially challenging due to the PEW.

TENSED COMPLEMENT CLAUSES THAT DO NOT CONTAIN A GAP. In the case of an embedded clausal complement structure, speakers can readily conceive of the content of the superordinate and embedded clauses as connected and so plan the clauses together. We suggest that the absence of the complementizer *that* in tensed complement clauses reflects such joint planning. This follows from our claim that reduced structures developed to facilitate this type of advance planning in cases of a close connection between the content of the two clauses. But the verb-complement relation does not always create enough connection for speakers to plan the two clauses together. In cases where speakers plan each clause separately, they will tend to use the full structure with *that* instead. This distinction corresponds to Ferreira and Dell's availability effect.

EXTRACTION OUT OF TENSED COMPLEMENT CLAUSES. An across-clause filler-gap relationship is incompatible with clause-by-clause planning. But unlike in subjacency structures, it is possible to plan for an embedded complement clause and the superordinate clause simultaneously, due to the relationship between the verb and its complement, as discussed above. This suggests that the production of a filler-gap structure over a clause boundary involves advance planning, resulting in the reduced structure without *that*. This handles the Pickering and Shillcock (1992) finding that across-clause subject and object extraction structures without *that* show the same subject preference as within-clause extraction structures. Since the two clauses are planned together, the subject gap is not at the beginning of a planning unit. The subject extraction structure is easier than the object extraction structure because the filler-gap distance is shorter.

On this account, the oddness of the object-gap structures with *that* (Cowart 1997) reflects the clash between the filler-gap relationship, which generally involves joint planning of the clauses, and the full structure with *that*, which reflects separate planning of the clauses. The marked unacceptability of the subject-gap structures with *that* (the *that*-trace cases) is due to this clash combined with the PEW. (Recall that Cowart used judgment data. But we assume that the judgments reflect a sense of how readily the sentences would be produced.)

Finally, our account also handles Culicover's (1993) observation that the subject extraction cases are grammatical in instances where the clause begins with a sentential adverbial. If the difficulty of across-clause subject extraction is due to planning for a gap at the onset of the clause, then intervening material is correctly predicted to alleviate the difficulty.¹³

¹³ Crosslinguistically, structures such as agreeing complementizers allow languages to circumvent the *that*-trace effect. These structures are likely to parallel the *that*-less complements in English, in the sense that they indicate a high degree of connectedness between the clauses. As a referee pointed out, the agreeing complementizer structure is an exception to the correspondence between degree of connectedness and amount of overt morphology. We suggest that the agreeing complementizer should be analyzed as a kind of contraction between the complementizer and the subject gap that results from the option of joint planning of the two clauses.

CHILDREN'S USE OF THE COMPLEMENTIZER *that*. Research on disfluency markers finds that children generally do less advance planning than adults (e.g. McDaniel et al. 2010). This would explain why they often produce the complementizer *that* in spite of the filler-gap structure. If they plan the two clauses separately, they must reconstruct the filler-gap relationship when planning the lower clause. Their lack of joint planning in this case is reflected by the use of the full structure with *that*, which leads to a *that*-trace violation in the case of a subject gap.

AVOIDANCE OF PASSIVE IN LONG-DISTANCE EXTRACTION. In within-clause extraction structures, it appears that speakers sometimes use the passive in order to substitute a subject-gap structure for an object-gap structure. Our account straightforwardly explains why speakers would avoid this in long-distance extraction. Subject gaps are harder than object gaps in these cases. So the passive structure would make planning more difficult (even without consideration of the added complexity of the passive structure itself).

RESUMPTIVE PRONOUNS. Speakers prefer gaps where planning of the filler-gap relationship is unproblematic, since the resumptive pronoun requires an extra word. The more difficult the filler-gap relationship is, the more useful the resumptive pronoun is. Since resumptives can refer to the filler independently (as pronouns), as well as syntactically (through binding), a speaker can rely on the independent reference if faced with an incompletely planned filler-gap relationship.

WITHIN-CLAUSE EXTRACTION IN RELATIVE CLAUSES. Now that we have covered the complex cases (part 2 of the mirror asymmetry), we turn to within-clause extraction structures. Our account straightforwardly handles a preference for subject gaps over object gaps in interrogative structures, since the filler and subject gap are adjacent. But relative clauses now seem problematic: the modified noun in a relative clause structure is in a clause higher than the one with the gap. The relative clause is an adjunct, not a complement; it is therefore less directly connected to the higher clause. Furthermore, elicited production research, along with corpus studies, shows that both adult and child English-speakers prefer *that* to introduce a relative clause in cases where it is optional, suggesting that the relative clause is a new planning unit. If our reasoning is correct, then all subject relative clauses should be difficult because the filler-gap relation is never within-clause.

We address this problem by considering the filler more carefully. Up to this point (as in much of the psycholinguistic and typology literature), we have not distinguished between the modified noun and the filler. In languages that introduce the relative clause with an overt WH-phrase, however, it seems natural to count it as the filler. Chomsky (1977) extended such an analysis to all relative clause structures, analyzing them as having a nonovert operator specifier. At the interpretative level, the modified noun is connected with the filler-gap relationship in the relative clause. If an analysis along these lines is correct, then our problem disappears, since the filler and gap are now in the same clause for within-clause relative clause extraction structures. But even without this analysis, we can appeal to the semantic relationship between the modified noun and the relative clause. The relative clause might be a new planning unit, but it is plausible that at its onset, the speaker has the modified noun in mind (i.e. the relative clause functions as an attribute of the head). This explains why starting a new planning unit with a subject gap in within-clause extraction structures is not just unproblematic; it is actually preferred: the filler is either part of the clause (if Chomsky's analysis is correct), or it is salient at the onset of the relative clause. Both cases fall under property 2, since the filler is salient when the gap occurs.

5. CROSSLINGUISTIC CONSIDERATIONS. Although most of our examples are from English, our account is intended to hold universally. As Jaeger and Norcliffe (2009) note, approaches that rely on purportedly universal processing principles require more crosslinguistic psycholinguistic research, especially in production. At this point, relatively little is known about the production and comprehension processes across diverse language types. Of additional relevance for our account, relatively little descriptive work focuses on across-clause extraction possibilities. For that reason, we limit our discussion in this section to several crosslinguistic structural configurations concerning part 1 of the mirror asymmetry. The first is the prenominal relative clause construction, which our account handles well. We also consider configurations that challenge our account. One of these is verb-final order, and the other is object-before-subject order.

5.1. PRENOMINAL RELATIVE CLAUSES. Processing preferences in within-clause extraction structures have been explored in several languages with prenominal relative clauses (Chinese: Chan et al. 2011, Gibson & Wu 2013, Hsiao & Gibson 2003, Hsu et al. 2009, Lin & Bever 2006; Japanese: Ishizuka 2005, Ueno & Garnsey 2008; Korean: Kwon et al. 2010, Suzuki 2011; Turkish: Hermon et al. 2010; Basque: Carreiras et al. 2010, Gutierrez-Mangado 2011, Gutierrez-Mangado & Ezeizabarrena 2012). Most of these are comprehension studies, and most find the same subject-gap preference that has been found in postnominal relative clause structures (with some inconsistency, which we return to below). Production findings from such languages, including both corpus (Carreiras et al. 2010, Hsiao & Gibson 2003) and experimental research (Gutierrez-Mangado & Ezeizabarrena 2012, Hermon et al. 2010, Hsu et al. 2009), also find the preference for subject relatives over object relatives.

Our account can explain why the subject-gap preference would hold for prenominal relative clause structures. The structure in such languages is as shown in 18. (We use SOV order to illustrate, since it describes most of these languages. Our account works the same way for SVO word order, as in Chinese.)

(18) [_{rc} subject object verb] Noun

A purely linear account predicts an object-gap preference, since the object position is closer to the head noun. Here we appeal to our notion of salience (property 2) combined with a proposal made by De Smedt (1994). De Smedt distinguished the order of elements in the utterance from the order in which they are formulated. Specifically, he pointed out that the utterance order would be limited by the language's word-order requirements, but that the formulation order would not be. The prenominal relative clause structure seems like an example of this discrepancy. The head noun would be formulated before the modifying clause, even though it is not uttered till afterward, since it is part of the main clause proposition. The head noun would therefore be salient at the onset of a prenominal relative clause, facilitating a gap-first (subject-gap) structure even if the filler is not at the beginning of the relative clause. Note that the findings on prenominal relative clauses are generally taken as indicating that the basis for the preference for subject relative clauses is hierarchical rather than linear. Our account is somewhat of a combination. Descriptively, the facts are most easily stated in terms of hierarchy (subject gaps are easier than object gaps, regardless of their position with respect to the modified noun). However, on our account, linearity plays a role in the order of planning. We claim that the noun (though not uttered yet) is activated immediately prior to the relative clause and that the closeness of the subject gap to the beginning of the clause (the point where the head noun is salient) facilitates the production of the subject-gap structure.

Some comprehension research finds an object-gap preference in Chinese (Gibson & Wu 2013, Hsiao & Gibson 2003) and in Basque (Carreiras et al. 2010, Gutierrez-Mangado 2011, Gutierrez-Mangado & Ezeizabarrena 2012). This appears to be a production/comprehension mismatch, most directly evident in Gutierrez-Mangado & Ezeizabarrena 2012, which compared comprehension and production of Basque in the same study. As Gibson and Wu (2013) pointed out, the production/comprehension mismatch can be attributed specifically to the knowledge that the speaker has about the structure, knowledge that is not shared by the listener. Whereas the speaker has the head noun in mind at the onset of the relative clause, initially the listener does not even know that the structure is a relative clause. In a subject-gap structure, the object within the relative clause can be mistaken for the object of the main clause (i.e. a garden path). The subject in an object-gap relative clause, by contrast, could signal that the structure is a relative clause. This does not explain the inconsistencies across different comprehension studies. Perhaps other factors play a role as well, such as ergativity, morphological marking of the relative clause, and the pronominal system.

5.2. VERB-FINAL LANGUAGES. SOV languages with prenominal relative clauses, such as Japanese, were mentioned above. These are accounted for the same way as SVO languages with prenominal relative clauses, like Chinese. In both cases, we claim that the subject position is closer to the onset of the relative clause, where the speaker plans the head noun. Verb-final languages with postnominal relative clauses, such as German, are handled straightforwardly. In this case, the head noun is actually uttered at the onset of the relative clause, as shown in 19.

(19) Noun [_{rc} subject object verb]

In this respect, these languages are no different from SVO (or VSO) languages with postnominal relative clauses.

However, verb-final word order indirectly challenges our account. This is because the PEW, which we rely on, seems not to apply in verb-final languages. Hawkins (2004, 2007, and p.c.) argues against the PEW on these grounds. He uses examples from Japanese and Korean, where corpus studies and production experiments indicate a preference for preposing, rather than postposing, heavy VP constituents (Choi 2007, Yamashita 2002, Yamashita & Chang 2001, 2006). Hawkins argues that the efficiency principle MiD (minimize domains) handles those effects in non-verb-final languages, as well as the preposing preference in verb-final languages.

Despite the problem raised by the Japanese and Korean data, we do not dismiss the PEW. Assuming that the pattern in these languages is characteristic of verb-final languages, we suggest an extension of the PEW to explain the lack of a light-first preference. As with the noun in prenominal relative clauses, the verb in a verb-final language is likely to be planned in advance. Again, unlike the listener, the speaker has the verb in mind well before it is uttered.¹⁴ If there is a heavy phrase in the VP, the speaker plausibly plans a lighter phrase along with the verb before uttering the heavy phrase. Again, the planning process does not necessarily match the linear order of the utterance. It is possible to plan a phrase first but not utter it first. In such cases, the PEW would not be buying time for the heavy phrase. Rather, it would allow the system to focus on the heavy phrase. We suggest then that the PEW has two parts that converge in non-verb-final languages, but conflict in verb-final languages, as shown in 20.

¹⁴ Hwang and Kaiser (2014) challenge the claim that the verb lemma must be determined in order to assign grammatical functions in verb-final languages. They found that Korean speakers plan at least the subject before selecting the verb's lemma.

(20) PEW EXTENSION

- a. Part 1—order of UTTERANCE: Utter the lighter phrase before the heavier phrase to buy time for the heavier phrase.
- b. Part 2—order of PLANNING: Plan the lighter phrase along with the head in order to focus on the heavier phrase.

This account predicts that heaviness will matter less to linear-order preferences in verb-final languages than in other language types. This is because in verb-final languages, the two parts of the PEW lead to opposite outputs. In order to handle the heavy-first preference in Japanese and Korean, however, we need to take the account a step further to explain why part 2 of the PEW overrides part 1 in these languages. We suggest that the answer lies in the fact that these languages are rigidly verb-final. In such languages, the verb is regularly accessed early relative to other elements of the clause. Thus, formulation out of utterance order is standard for sentence planning in these languages. Part 2 of the PEW would therefore fit the general approach to formulation better than part 1.¹⁵

5.3. OBJECT-BEFORE-SUBJECT ORDER. Our discussion so far has generally assumed that the subject is the first element in the clause. This is true for the two most common word orders, SOV and SVO. Our account extends to VSO languages as well, since the subject precedes the object and is closer to the beginning of the clause. However, the rare languages with object-before-subject order are problematic for our account, which predicts that object gaps would be preferred over subject gaps in within-clause filler-gap structures in these languages. This prediction appears to be false, based on languages like Malagasy, with both VOS word order and postnominal relative clauses (Keenan & Comrie 1977). We leave this problem for future research.¹⁶

6. PARSING VS. PRODUCTION. In this section we compare parsing- and production-based accounts of extraction phenomena. Production and parsing principles might shape the grammar cooperatively, and in many cases it is difficult to tease the two apart. MacDonald and colleagues (Gennari & MacDonald 2009, MacDonald 2013, MacDonald & Thornton 2009, Race & MacDonald 2003) argue that parsing principles reflect sentence-formulation processes that show up as parsing phenomena only because parsing facility is affected by frequency of usage.¹⁷ Various studies suggest that speakers' choices do not reflect avoidance of local ambiguity, indicating that the parser is not considered in sentence formulation (Ferreira & Dell 2000, Rohdenburg 1996, Wasow 2002).¹⁸ By contrast, certain aspects of grammar, such as morphological case marking, seem more readily attributable to the needs of the parser than to those of the producer.

¹⁵ In nonrigid verb-final languages, the winning part of the PEW might depend on factors such as salience. Light phrases that are also highly salient would be easier to hold in memory along with the verb. In §6, we further consider the issue of why the effects of the PEW should not be subsumed under MiD.

¹⁶ Hawkins (p.c.) points out that many object-before-subject languages also have an ergative case system, which raises questions about the notion of subject, complicating the matter further.

¹⁷ But see Grodner and Gibson (2005), who tested parsing difficulty at specific points in the sentence using a self-paced reading task, and contrasted points of infrequent structure with other parts of the structure. Their findings suggest that frequency is not the (sole) determining factor, and they argued for a parser-specific account that is based on limited resources.

¹⁸ However, Temperley (2003) argues that sentence formulation strategies deriving from general considerations of disambiguation do play a role in structural choices. See also Jaeger (2013), who argues that accounts of language form based on production biases alone are insufficient and that the goal of effective communication must also be relevant.

Hawkins's efficiency principles handle many aspects of filler-gap structures, including part 1 of the mirror asymmetry. Hawkins derives the accessibility hierarchy from MiD. The effect in filler-gap structures is a preference for the filler-gap relation to be determinable within a small domain. Hawkins proposes that the smallest domain in which a filler-gap relationship can be determined is the FILLER-GAP DOMAIN, as stated in 21.

- (21) FILLER-GAP DOMAIN (FGD): An FGD consists of the smallest set of terminal and nonterminal nodes dominated by the mother of a filler and on a connected path that must be accessed for gap identification and processing; for subcategorized gaps the path connects the filler to a coindexed subcategorizer and includes, or is extended to include, any additional arguments of the subcategorizer on which the gap depends for its processing; for nonsubcategorized gaps the path connects the filler to the head category that constructs the mother node containing the coindexed gap; all constituency relations and cooccurrence requirements holding between these nodes belong in the description of the FGD. (Hawkins 2004:175)

The FGD/MiD is the parsing counterpart to property 2 in our production account (dependency relationships are preferred when the antecedent is salient). Hawkins argues that the parser can identify the subject gap using the verb alone, but that both the subject and the verb are necessary for the identification of an object gap, since the object is syntactically and semantically dependent on the subject. This results in a larger FGD for object gaps, explaining why object relative clauses are lower on the accessibility hierarchy.

Hawkins's efficiency principles also handle phenomena involving the extraction of nonsubjects out of complex domains. The size of the FGD increases with the structures on the clause-embedding hierarchy for gaps, explaining why extraction is easier out of infinitival clauses and hardest out of subjacency structures.

Our production account also echoes Hawkins's account of the distribution of resumptive pronouns. MiF (minimize forms) and MaOP (maximize on-line processing) result in a preference for less overt material, so that gaps are generally preferred over overt counterparts. But in complex structures, the large FGD makes gap structures especially difficult, overriding the slight preference for nonovert material. Resumptive pronouns are then preferred over gaps. Although coindexation between the filler and resumptive pronoun is still necessary (as in the case of a filler and gap), the overt pronoun facilitates lexical processing of the unit that contains it, avoiding the parsing difficulties created by a gap.

The two accounts diverge with respect to part 2 of the mirror asymmetry. Hawkins (2004) attributes the *that*-trace effect to the overt complementizer rather than to the gap. On his account, the tensed lower verb signals the subordinate clause, making the overt complementizer functionally useless. Instead, it lengthens the FGD, as well as the lexical domain for processing the arguments of the lower verb. (The lengthened FGD would also explain why a null complementizer is preferred over *that* in the object-gap structure.) But Hawkins does not consider subject extraction in subjacency structures, which show the same subject/object asymmetry as the *that*-complement structures. His account of the *that*-trace effect does not extend to such cases, since WH-phrases do not function simply to mark a clause boundary and therefore are not dispensable.

Our account and Hawkins's also differ in how they handle the crosslinguistic word-order data discussed in §5. Hawkins relies in part on the characterization of the FGD in terms of the filler-subcategorizer relationship rather than the filler-gap relationship. The filler-subcategorizer relationship makes sense for a parsing-based account, since the

subcategorizer gives the parser the information it needs to find the gap. For a production account, in contrast, the filler-gap relationship is more plausible, since the speaker needs to PLAN the gap rather than FIND it. In other words, the speaker already knows how the gap fits into the structure semantically; the challenge for the speaker is to formulate the structure containing the gap. Recall that Hawkins's FGD for an object gap must include the subject, but that the FGD for the subject gap need include only the subcategorizer (i.e. the verb). This way, as long as the verb is closer to the filler than the object position, Hawkins's account makes the right predictions for within-clause relative clause extraction. Unlike our production account, the parsing account can handle object-before-subject (VOS) word order. Since the filler (the head noun) is adjacent to the verb, subject relatives are correctly predicted to be easier than object relatives, even though the object position is closer to the filler than the subject position. But our account is more successful than Hawkins's for cases where, due to a language's word order, the direct object's position within the relative clause intervenes between the verb (subcategorizer) and the filler. In these cases, the FGD is the same size for subject gaps and direct object gaps. There are two such cases: SOV word order with postnominal relative clauses (such as German), and SVO word order with prenominal relative clauses (such as Chinese). Our account handles the first of these straightforwardly since the subject gap is adjacent to the head noun, as discussed in §5.2. Our account also handles the second case, if we assume that the head noun is planned by the speaker at the onset of the relative clause, as discussed in §5.1.

Finally, we return to the PEW, which Hawkins subsumed under MiD in order to handle word-order patterns in verb-final languages. We suggested in §5.2 an extension of the PEW that explains why the light-first order does not hold in verb-final languages. We must still ask why the effects of the PEW should not be subsumed under MiD, as Hawkins suggests, especially since it straightforwardly predicts the heavy-first preference in these languages. We see two problems in the application of the MiD account here: it does not explain the difficulty of embedded subject gaps, and it does not straightforwardly extend to language production. We discuss these two problems in turn.

Recall that the PEW is essential to how we handle the difficulty of embedded subject gaps. Since clauses are planning units and gaps are hard to plan, the PEW explains the challenge of an early gap in an embedded clause. MiD, by contrast, does not make the right predictions. As discussed earlier, the lack of an uttered subject at the onset of a clause is highly informative for the parser. This is especially true of a non-null-subject SVO language like English; the verb will be the first overt element of the clause, allowing the parser to immediately construct the clausal node, the subject (gap), and the VP. In other words, one word (the verb) reveals a great deal of structure, which should make the construction highly preferred.

Our second concern is with the nature of MiD. Originally concerned with parsing, Hawkins (2004) extended MiD to production. His motivation was research showing the benefits of ordering preferences in production, as well as the research indicating that local ambiguity does not seem to be a factor in ordering preferences. However, he did not specify production-based arguments for MiD. The point of MiD is that certain word orders facilitate the process of determining phrasal nodes. But the speaker knows the structure before uttering the words and therefore is not trying to figure out the phrasal nodes. For this reason, as Wasow (2002) argues, the PEW provides a more plausible account of the production process.

Overall, the production account is more successful than the parsing account with respect to extraction phenomena. Most importantly, the production account handles both

parts of the mirror asymmetry in a uniform manner. We emphasize, however, that our account is not intended to replace Hawkins's efficiency principles, which handle many and varied phenomena. Again, we think that production and parsing principles both contribute to shape grammars.

7. SUMMARY AND CONCLUSIONS. Although we argue here for a greater role for language production, we agree with Hawkins's and Newmeyer's fundamental claim that grammars are shaped by the processing systems. Like Newmeyer (2005), we do not see such work as undermining any notion of a competence grammar. In fact, we find it quite plausible that a faculty of language in the narrow sense (FLN) consisting of Merge could have been the primary evolutionary innovation that led to human language in its modern form and would constitute the core of human grammatical competency (Chomsky 2008b, 2010, Hauser et al. 2002). We suggest that the processors would have been influential for externalization, or the application of Merge to communication. Faced with the challenging task of rapidly producing and comprehending novel strings, the processors would have developed procedures and heuristics that yield the intricate preference patterns that are the primary empirical manifestation of the core grammar. But such differences could not be seen as a derivation from the core (in the sense that a language-particular grammar might be seen as a set of parameter settings). Rather, a language-particular grammar would arise by way of a three-way interaction among the core grammar, the processing systems, and what we are calling the linguistic ecosystem—the lexical resources, morphological patterns, ordering tendencies, and other features that constitute the materials available for the construction of sentences. The resulting patterns of preference could only be specified by adding parameters that are generally regarded as irrelevant to the core grammar (e.g. domain size, linear order, planning order, salience, overtiness, etc.). On such a model, knowledge of a particular language must, by definition, include specifics of the lexical and morphological materials of a language to which the universal core grammar is blind. Since speakers can respond to processing pressures in a variety of ways, the possibilities for variation are less deterministic than the parameters of the principles-and-parameters framework. Children could be innately equipped with FLN, with processing systems, and with procedures and preferences that could both limit and expand the range of structures available. The language acquisition process would then include figuring out the devices used by a particular language to respond to the constraints implicit in FLN. A challenging filler-gap relation, for example, might be ungrammatical in some languages and instantiated with special devices (resumptive pronouns, etc.) in others.

We believe that an approach to modeling of the sort we have described here merits further investigation. Comprehension and production processes have a more central role in accounting for linguistic diversity than has generally been recognized. Systematic attention to their contributions is essential to the broader integration of grammatical and processing theories.

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