DOMAIN MINIMIZATION IN ENGLISH VERB-PARTICLE CONSTRUCTIONS

Barbara Lohse — University of Southern California
John A. Hawkins — University of Southern California
Thomas Wasow — Stanford University

The placement of the particle before or after an object in the English verb-particle construction is influenced by a variety of factors. We argue that many of them can be subsumed under a single simple principle, motivated by considerations of processing efficiency: to the extent that the domains of syntactic and semantic dependencies can be minimized, processing is facilitated. We use a more precise formulation of this idea to make several predictions about the distribution of particles based on the size of the object NP and the semantic dependencies among the verb, the particle, and the object. Corpus studies confirm the predictions, providing evidence for the principle of domain minimization.*

1. Introduction. English verb-particle phrases display a basic syntactic alternation: verb and particle can occur either joined, as in 1a, or split, as in 1b.

(1) a. She $_{VP}$[looked up $_{NP}$[the number]]
b. She $_{VP}$[looked $_{NP}$[the number] up][1]

Numerous factors have been proposed to account for the distribution of joined vs. split orders in English performance. Most of these factors fall into one of three groups: syntactic factors like the length of the NP (e.g. Chen 1986, Hawkins 1994), semantic factors like the degree of idiomaticity (e.g. Fraser 1976, Chen 1986), and discourse factors like givenness (e.g. Chen 1986) or focus (e.g. Dehé 2002). These studies often focus on just one factor at the expense of others. If they consider multiple factors, it is unclear how they interact. What is also lacking in this research literature is a satisfactory explanation for the distribution.

In his recent corpus study of particle placement, Gries (2003) demonstrated the need for a multifactorial approach. He initially considers all twenty-five factors that have ever been proposed and eliminates those that prove to be statistically insignificant. He then shows how the remaining factors can be subsumed under THE PROCESSING HYPOTHESIS; that is, they all relate to differences in processing cost for different orderings. In order to do this, however, he has to appeal to a variety of theoretical frameworks and to processing principles that range from the proposed processing cost associated with identifying and activating referents in discourse (e.g. Givón 1992, Lambrecht 1994) to that associated with various constituent orders (e.g. Hawkins 1994).

We take a different approach here. We integrate several of the factors that have traditionally been proposed to affect ordering preferences into a single and simple principle of processing efficiency and complexity. We argue that the ordering preferences that can be observed for verb-particle phrases in performance data are strongly linked to the overall size of the processing domains for the various syntactic and semantic relations that are involved in these constructions. Applying the theoretical framework

*We are grateful to Pete Alrenga for help with the extraction and coding of the data. Colin Bannard gave us helpful comments on an earlier version, as did two anonymous *Language* referees, and editors Brian Joseph and Richard Oehrle. We take responsibility for any remaining shortcomings.

[1] Intransitive verb-particle phrases are also extremely common in English, but, in the absence of a direct object NP, they do not show a reordering possibility like the one shown in 1a and 1b, nor do they allow reordering involving other constituents (e.g. *The enemy gave up quickly*/**The enemy gave quickly up*), and were therefore excluded from our study.

presented in Hawkins 2001, 2003, and 2004, we focus on two types of basic relations: combinatorial and dependency relations.

A relation of COMBINATION is defined in 2.

(2) Combination
Two categories A and B are in a relation of combination iff they occur within the same syntactic mother phrase or maximal projection (phrasal combination), or if they occur within the same lexical cooccurrence frame (lexical combination).

The phrasal combinations of a language are determined by its phrase-structure rules: a verb combines with a direct object NP within the same VP, the subject combines with the VP within S (or IP), and so on. Subjects, objects, and other complements are also in a relation of lexical combination with the verb and are listed in its lexical entry; adjunct phrases are not so listed.

The definition for DEPENDENCY given in Hawkins 2001, 2003, and 2004 is summarized in 3.

(3) Dependency
Two categories A and B are in a relation of dependency iff the parsing of B requires access to A for the assignment of syntactic or semantic properties to B with respect to which B is zero-specified or ambiguously or polysemously specified.

For example, the subject NP in *The key opened the door to the wine cellar* is zero-specified with regard to its theta-role and the parser needs to access the following VP in order to assign the instrument role.[2]

For each combinatorial and/or dependency relation between two categories, we now define a DOMAIN within which the relevant assignments are made in processing.

(4) A combinatorial or dependency domain consists of the smallest connected sequence of terminal elements and their associated syntactic and semantic properties that must be processed for the production and/or recognition of the combinatorial or dependency relation in question.

For a syntactic alternation like the one observed for transitive verb-particle phrases, this theoretical framework allows us to define the relevant combinatorial and dependency relations and their respective processing domains and to determine the extent to which different orderings impact domain sizes individually and collectively. Hawkins's efficiency principle of MINIMIZE DOMAINS (MiD), defined in 5, predicts that orderings that result in minimal domain sizes will be preferred in performance.

(5) Minimize domains (MiD)[3]
The human processor prefers to minimize the connected sequences of linguistic forms and their conventionally associated syntactic and semantic properties in which relations of combination and/or dependency are processed.

[2] Notice that the definition for combination in 2 is given in purely grammatical terms, whereas the definition for dependency in 3 is ultimately a processing one, in terms of the required access to one category while parsing another. Hawkins (2001, 2003, 2004) argues in detail for this definition and tests numerous predictions derivable from it for performance and grammars.

[3] The complete definition of MiD given in Hawkins 2003 adds a second clause: 'The degree of this (MiD) preference will be proportional to the number of relations whose domains can be minimized in competing sequences or structures, and to the extent of the minimization difference in each domain' (123).

Minimal domains are efficient since the relevant combinatorial and dependency relation can be processed faster and with less simultaneous processing of additional (phonological, morphological, syntactic, and semantic) properties within the relevant domain.

Minimize domains is one of a small set of general principles of efficiency and complexity that can explain many seemingly different variation phenomena in performance and in grammars (Hawkins 2003, 2004). In this context we show how MiD is the ultimate driving force behind several syntactic and semantic factors that have been proposed for particle placement, that this one overarching principle can account for a large amount of the variance in the data, and that it makes predictions that previous studies have not made. For example, MiD predicts that the selection of joined vs. split order is influenced by different types of semantic dependency as defined here, as well as by the precise positioning of the head noun within the object NP.

We propose five combinatorial and/or dependency domains for transitive verb-particle phrases, and we test the predicted domain-minimization effects on performance data taken from four corpora: the Brown Corpus, the Lancaster-Oslo/Bergen Corpus, the Wall Street Journal Corpus, and the Switchboard Corpus. All the predictions are confirmed by the data.

2. VP PHRASAL COMBINATION DOMAINS.

2.1. PREDICTIONS. The verb phrase in 1a and 1b consists of three syntactic categories, a verb, a particle, and an object noun phrase. The precise constituent structure linking these three categories has been the subject of much debate.[4] Our goal is to remain as neutral as possible regarding the differences between syntactic analyses and to present our definitions and findings in terms that are compatible with many theories. Every theory must incorporate the basic properties of cooccurrence, dependency, and order holding between these three surface categories, and it is these basic properties that are defined here. We show that significant results can be attained on the basis of these properties alone, without making additional structural assumptions.

Our first processing domain, a VP PHRASAL COMBINATION DOMAIN, refers to the surface material that must be processed for the production and/or recognition of the VP and its three constituents, verb, particle, and NP.

(6) VP phrasal combination domain (VP PCD)
The PCD for a VP containing a transitive verb-particle phrase consists of the smallest contiguous substring containing the verb, the particle, and the first constructing word in the object NP.[5]

The basic idea behind establishing syntactic processing domains like PCDs is that orderings can differ with regard to the amount of material that needs to be processed in order to construct a mother node like VP and the immediate constituents (IC) of this mother: the less material in the domain, the faster phrase-structure processing can be.

[4] See, for example, the discussions in Dehé 2002 and Jackendoff 2002.

[5] This definition makes no assumptions about any further branching structure within the VP linking the verb and the particle. It assumes only a VP and the three daughter constituents, verb, particle, and NP. The first constructing word of a phrase is understood to be the first unambiguous on-line signal to a parser that permits reliable inferences to be drawn about dominating structure (cf. Hawkins 1994:60–64). For discussion of the relationship between parsing and production with respect to phrasal combination domains, see Hawkins 1998 and 2004.

A PCD for the VP can be measured in IC-to-word ratios.[6] The fewer words that are needed for construction of all ICs, the higher the IC-to-word ratio, as illustrated in 7.

(7) a. Joe $_{VP}$[looked up $_{NP}$[the number of the ticket]]
1 . . 2 . . . 3
VP PCD: IC-to-word ratio of 3/3 = 100%

b. Joe $_{VP}$[looked $_{NP}$[the number of the ticket] up]
1 . . . 2 . . . 3 . . . 4 . 5 . . . 6 . . 7
VP PCD: IC-to-word ratio of 3/7 = 43%

The same constituency information can be constructed in the three-word domain of 7a as in the seven-word domain of 7b. As a result, phrase-structure recognition (Hawkins 1994) and production (Hawkins 2004) can be accomplished sooner and there is less additional (phonological, morphological, syntactic, and semantic) processing that needs to occur simultaneously with phrase-structure processing.

The optimal IC-to-word ratio of 7a holds regardless of the length of the object NP; that is, it does not change however long the NP is, since the particle remains constant at one word in these examples, and the NP is assumed to be constructed at its left periphery.[7] NP-length is, however, crucial for the VP PCD in the split ordering of 7b, in which an optimal IC-to-word ratio of 100% is possible only for NPs of just one word. As the length of the NP increases, the ratio decreases, and the split ordering becomes less and less efficient for rapid phrasal construction.

Our definition and measurement of PCDs for verb-particle phrases builds on Hawkins's (1994) principle of EARLY IMMEDIATE CONSTITUENTS (EIC), which is now subsumed under the more general principle of minimize domains (5). Orderings that have smaller PCDs are preferred over those with larger ones, since phrase-structure processing is faster and there are fewer simultaneous processing demands on this particular task.

(8) Early immediate constituents (EIC) (Hawkins 1994:69–83)
The human processor prefers linear orders that minimize PCDs (by maximizing their IC-to-word ratios) in proportion to the minimization difference between competing orders.

It turns out that the EIC-based calculations that predict domain-minimization effects for PCDs lead to basically identical results under very different assumptions about VP-internal structure.

Domain-minimization effects should be most visible in the corpus data when there is some appreciable difference in domain size between the split and the joined ordering. The factor that determines the size of the VP PCD in each ordering is the length of the object NP. For short NPs (one to two words), the difference between the two PCDs

[6] The 'IC-to-word ratios' serve as shorthand for quantifying 'IC-to-non-IC ratios', that is, the ratio of ICs to all other terminal and nonterminal nodes in the domain (cf. Hawkins 1994:69–83). Wasow (1997, 2002) conducted several tests on corpus data to compare calculations of weight using different non-IC nodes and concluded that they were statistically equally good predictors. Earlier attempts by Hawkins and Wasow to calculate weight using phonological factors such as syllables did not yield better results than a word count (cf. Rickford et al. 1995:111). By contrast, Gries (2003) claims that number of syllables is a slightly better predictor for particle placement than number of words. But, as we point out in §5, he did not apply a permutation test and his data contain many direct objects with a (one-syllable) personal pronoun immediately preceding a (one-syllable) particle, which makes this finding less conclusive. Prosodic factors may indeed contribute to the weight of a constituent (see the discussion of this point in Green 2004), but there is plenty of evidence that weight effects are not entirely prosodic (cf. Wasow 2002 and Rickford et al. 1995).

[7] Particle phrases are not limited to single word phrases. They can also include adverbs and/or prepositional phrases.

is small, and no clear ordering preference is predicted. With increasing NP-length, however, the relative processing advantage of the joined ordering increases through PCD minimization, and this should result in an increasing preference for placement of the particle adjacent to the verb. In about half of our corpus data the verb-particle phrase contains an object NP longer than two words, so we can expect that NP-length will be one of the factors that plays an important role in the choice of ordering.

(9) Prediction 1 (VP PCDs)
The length of the object NP will be a significant factor for performance preferences regarding the adjacency of verb and particle. With increasing length of the object NP there will be an increasing preference for adjacency of the verb and particle.

2.2. Testing prediction 1. The robustness of length effects has been shown in various corpus studies on verb-particle phrases and other syntactic alternations, both in isolation and also in interaction with other factors that have been proposed to affect constituent ordering (e.g. Gries 2003, Hawkins 1994, 2000, 2004, Wasow 2002). Nevertheless, for completeness we tested prediction 1 on our corpus materials.

We compiled a database consisting of 1,684 verb-particle phrases extracted from four corpora: the Brown Corpus (410 items) and the Lancaster-Oslo/Bergen Corpus (LOB) (237 items), both of which were drawn from a broad range of printed text types in American English and British English respectively; the Wall Street Journal Corpus (WSJ) (287 items); and the Switchboard Corpus (750 items), a corpus of spoken American English consisting of adult telephone conversations.

The data extraction followed two criteria. We selected only those transitive verb-particle phrases that had no following ICs in the relevant clause in order to eliminate any possible effects these ICs could have on the positioning of the particle. Such ICs might constitute a phrase headed by the particle (a particle phrase) or they could attach directly to VP.[8]

The second selection criterion was permutability: both the split and the joined order had to be grammatically possible; that is, the speaker or writer had to have a choice. Verb-particle phrases containing a personal pronoun as NP were therefore excluded since the split construction is fixed by the grammar in these cases (*She lifted it up*/ **She lifted up it*). Also excluded were items with other pronominal NPs like demonstratives (*She lifted that up*), possessives (*She lifted hers up*), and reflexives (*It warms itself up*). Although the split construction is not obligatory here, the data showed a very strong preference (95%) for that order. In accordance with permutability, we also excluded verb-particle phrases containing semantically modified particle phrases (as in e.g. *they brought the chairs right up*), since they usually occur only in the split order,[9] as well as verb-particle phrases where the NP has become part of the idiomatic meaning of the entire phrase, making them nonpermutable, as in *take up arms*, *kick up a fuss*, or *sob one's heart out*.

There were a number of joined phrases in our initial database that did not fall into any of these categories and that seemed less acceptable to native speakers in the split order. Many of these cases, however, involved NPs of considerable length, which has been shown to influence acceptability judgments in experiments (Hunter 1981,

[8] See Gries 2003 for a discussion of the effects of a directional PP following the verb-particle phrase.

[9] Verb-particle phrases containing semantically-modified particles are actually quite rare in the corpora we searched. Despite our initially very large samples, we found only very few instances of semantic modification. Gries (2003:72) reports the same finding for the British National Corpus. See also §5 for a brief discussion of particle modification and domain size.

Hunter & Prideaux 1983) and which is predicted here to result in declining acceptability, so we decided to leave them in the database.

For Switchboard, all verb-particle phrases that fit the above criteria were included. For Brown and WSJ, all eligible split items were selected, but since we had eliminated a large number of split items (with pronominal NPs), we also limited the number of joined items in order to reflect the original ratio of all split to all joined phrases in these corpora. The tagging of LOB made it difficult to calculate the overall split/joined ratio. All eligible split items were again included, but the number of joined items selected may not reflect an overall ratio that was difficult to determine. Table 1 shows the distribution of split to joined verb-particle phrases in the database by corpus.

CORPORA	TOTAL # OF ITEMS	# OF SPLIT ORDERINGS	# OF JOINED ORDERINGS	% OF SPLIT ORDERINGS
Switchboard	750	229	521	31
Brown	410	86	324	21
WSJ	287	39	248	14
LOB	237	83	154	35

TABLE 1. Split vs. joined by corpus.

The relevant coding of the data for VP PCD minimization effects is by NP-length, measured in number of words.[10] The split ratios shown in Figure 1 support our first prediction of an increasing preference for adjacency between verb and particle with increasing length of the NP.[11] A first steep decline of the split ratio can be observed as the NP-length reaches three words, and a second one for five-plus words, where the preference for the joined ordering reaches an overwhelming 97%. For NPs greater than eight words, there were no split orderings.[12] These steep declines in the split ratio appear to be indicative of more complex phrase structure in addition to more terminal material.[13]

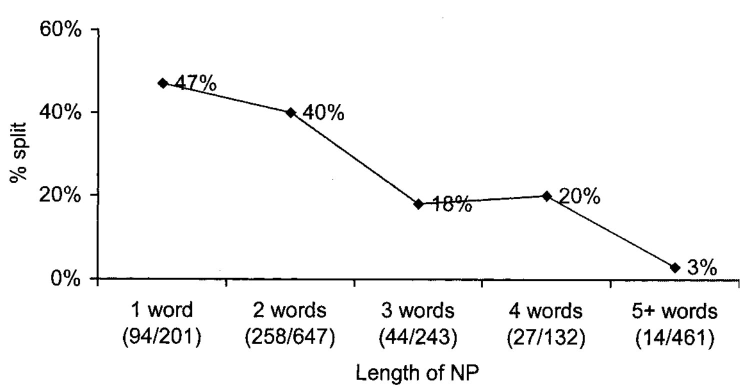

FIGURE 1. Split vs. joined by NP-length.

[10] More coding criteria are specified in the discussion of the other processing domains for which they are relevant.

[11] Statistical results for the overall significance of NP-length as a factor for ordering preferences are given in §3.5.

[12] Gries (2003) finds very similar results for the British National Corpus, with three words as the threshold for a clear adjacency preference, and seven words as the longest tolerated NPs for the split ordering.

[13] A three-word NP is more likely to contain a modifier in addition to a determiner or qualifier; an NP of five or more words is more likely to contain postnominal modifiers such as prepositional phrases or relative clauses.

3. Lexical dependency domains.

3.1. Dependent particles and verbs. The second type of processing domain that needs to be defined for verb-particle phrases is a lexical dependency domain (LDD). The general idea here is that the parser needs to access one category to assign certain semantic and/or syntactic properties to another (see the definition of dependency given in 3 above). Relations of dependency have to be considered between all three pairs of categories in the verb-particle phrase, that is, between the verb and the particle, between the verb and the object NP, and between the particle and the object NP.

Looking at the semantic relation between verb and particle, a classification proposed by Hawkins (2000) in his study of the relative ordering of prepositional phrases in English provides a diagnostic of use in this context as well. He devises two separate entailment tests that allow for each V and each PP in his corpus of [V PP_1 PP_2] phrases to be classified as either dependent (V_d/PP_d) or independent (V_i/PP_i). A phrase like *John waited for Mary at noon* would be classified as V_i PP_d PP_i. It entails *John waited* and *John did something at noon*, but not *John did something for Mary*. Only the second PP, *at noon*, is detachable from the verb and independently processable. By contrast, for the phrase *John counted on his son in old age*, *John counted* is not entailed, nor is *John did something on his son*. The verb depends on the first PP for its interpretation and the latter depends on the former. The classification is, therefore, V_d PP_d PP_i. Again, the two PPs following the verb differ with regard to their degree of dependency on it (Hawkins 2000:241–43). As predicted, the strongly preferred ordering for a VP consisting of one dependent and one independent PP of equal length was [V PP_d PP_i], with a minimal LDD for PP_d through adjacency with the verb (Hawkins 2000:245).

Hawkins's classification builds on an earlier study of heavy-NP shift by Wasow (1997, 2002). Wasow classified V-PP collocations as either semantically transparent or opaque, that is, noncompositional and with stronger semantic dependencies than a transparent one. He found that opaque collocations in his corpus occurred significantly more frequently in the noncanonical V-PP-NP order than did transparent collocations (Wasow 2002:84–85).

A similar effect with regard to the semantic relation between verb and particle has been pointed out in numerous studies on particle placement.[14] The most common form of classification is between 'idiomatic/opaque' and 'literal/transparent' meanings (e.g. Fraser 1976, Chen 1986, O'Dowd 1998). The consensus is that idiomatic particle verbs exhibit stronger adjacency between verb and particle than literal ones. Some studies propose to form a third group for particles that add aspectual meaning to the verb (Pelli 1976, Dehé 2002). The results of Dehé's production experiment on particle placement, however, reveal no significant difference between idiomatic and aspectual particle verbs with regard to adjacency. Gries (2003) also applies a three-way distinction. He adds a third group of 'metaphorical' meanings as an intermediate category between literal and idiomatic meanings.

A classification of verb and particle with regard to whether each of them is independently processable relates the factor of compositionality to the principle of domain minimization. The verb entailment test in 10 and particle entailment test in 11 have been adapted in the present context from Hawkins 2000.

[14] See the discussion in Gries 2003, among others.

(10) Verb entailment test
If [X V NP Pt] entails [X V NP], then assign V_i. If not, assign V_d.

(11) Particle entailment test
If [X V NP Pt] entails [NP PredV Pt], then assign Pt_i. If not, assign Pt_d.
PredV = predication verb (BE, BECOME, COME, GO, STAY)[15]

These entailment tests lead to four possible combinations of verbs and particles with regard to their dependency on each other. The first combination, V_i Pt_i, reflects a fully compositional meaning with both elements being independently processable. Examples are *they lifted up the child* or *they brought in the chair*. *They lifted the child* and *they brought the chair* are entailed respectively (cf. 10). The relevant entailment relations also hold for the particles: *the child GOES up* and *the chair GOES in* (cf. 11).

The other end of the compositionality spectrum is reflected in the combination of V_d Pt_d, where both verb and particle depend on each other for their interpretation. *They looked up the number* or *they carried out a repair* do not entail *they looked the number* or *they carried a repair*. Equally, there are no entailments for the particles. It is not entailed that *the number IS/BECOMES/COMES/GOES* or *STAYS up* or that *the repair IS/BECOMES/COMES/GOES* or *STAYS out*.[16]

For the remaining two combinations, only one of the two elements can be processed independently. Examples for V_i Pt_d are *they washed up the dishes* or *they helped out a friend*. The verb entailment test goes through with *they washed the dishes* and *they helped a friend*, but for the particles, neither *the dishes ARE up* nor *the friend IS out* is entailed.[17] The reverse, V_d Pt_i, can be found in *they dug up some plants* or *they turned on the light*. Entailment relations hold for the particles with *the plants COME up* and *the light GOES on*, but not for the verbs. *They dug some plants* and *they turned the light* are not entailed. The classification for those two examples is, therefore, V_d Pt_i.[18]

For verb-particle phrases that contain a dependent verb, access to the particle is required in order to assign to the complex verb properties like its syntactic requirements of cooccurrence or strict subcategorization restrictions (Chomsky 1965), semantic requirements of cooccurrence or selectional restrictions (Chomsky 1965), and the appropriate lexical-semantic content.[19] The entailment test for *they looked the number* (*up*) fails since there is no matching syntactic cooccurrence frame in the lexicon. For *they dug some plants* (*up*), no semantic cooccurrence frame can be found, and for *they turned the light* (*on*) the appropriate meaning is not available.

For independent particles, we can identify a distinct meaning that is assigned to these items when they occur outside a verb-particle phrase, for example, *trips up/down a*

[15] The predication verbs selected here test for the two main semantic features of the literal meaning of particles, according to Bolinger (1971:85): motion-through-location and terminus or result. See also Wurmbrand's (2000) proposal to classify a particle verb as transparent if the particle can be a copula predicate, that is, using only BE as a possible predication verb. McIntyre (2002:101) correctly points out the limitations of that test as it excludes cases that are clearly fully compositional.

[16] We consider an entailment using any of these predication verbs sufficient. In the following, we give only one entailment with the predication verb that works best.

[17] No other predication verbs listed in the test description produce an entailment either; BE is simply used as shorthand.

[18] Further examples to illustrate our classifications can be found in the appendix.

[19] For a detailed discussion of dependency relations between two categories and the syntactic and semantic properties involved, see Hawkins 2004.

mountain or *juice in boxes*.[20] Whatever meaning may be assigned to a dependent particle is clearly restricted to that particle occurring within a verb-particle phrase, that is, in combination with a verb. In many cases, a dependent particle makes no discernible semantic contribution to the verb-particle combination (cf. *help out a friend*). On other occasions there is a clear semantic contribution, as in the perfective use of *up*, for example, in *they filled up the barrel* or *they ground up the chilies*. McIntyre (2002:98) argues that particles like perfective *up* should be assigned a 'construction-specific' meaning, that is, a meaning that is accessible only within the verb-particle combination, but is not limited to combining with one particular verb.[21] In his view, phrases like *drink up the water* or *burn up the papers* differ substantially from noncompositional verb-particle phrases since the particle makes a semantic contribution, even though it is not necessarily related to the meaning of *up* in isolation, that is, its spatial interpretation. In the majority of cases of aspectual use of *up*, McIntyre points out, the base meaning of the verb is not affected (McIntyre 2002:97). According to our entailment tests, these cases are usually classified as V_i Pt_d, thereby capturing a certain degree of compositionality, in contrast to V_d Pt_d phrases that are fully noncompositional. With regard to the classification of particles, they clearly form a scale that ranges from a literal (spatial) meaning to an almost completely reduced meaning. The amount of the semantic contribution of the particle in individual cases seems hard to measure. As Bolinger (1971) points out, in some cases even a highly compositional meaning, although not spatial, can still be related to that spatial meaning (cf. *bring up a child*). The question is, however, to what extent such a relationship is actually transparent to the language user. The distinction between particles that can receive the same interpretation inside and outside the verb-particle phrase, and those with different interpretations, captures an appropriate cut-off point on the scale for a binary coding. Although dependent particles may vary in the degree of their semantic contribution, the crucial point is that they can be interpreted only in combination with the verb, and their semantic features are ultimately assigned to the verb-particle pair.

3.2. PARTICLE DEPENDENCY DOMAINS AND THEIR PREDICTIONS. Based on the dependency relations between particles and verbs discussed above, we can now define a LEXICAL DEPENDENCY DOMAIN FOR DEPENDENT PARTICLES.

(12) Pt_d-V lexical dependency domain (Pt_d-V LDD)
The LDD for a dependent particle (Pt_d) consists of the smallest contiguous substring that contains the Pt_d and the verb on which it depends for semantic and/or syntactic property assignments.[22]

(13) a. look $_{NP}$[the number] up_d
Pt_d-V LDD 1 2 3 4

b. look up_d $_{NP}$[the number]
Pt_d-V LDD 1 2

In the split ordering 13a, the size of the Pt_d-V LDD is determined by the length of the object NP. As with VP PCDs, increasing length of the NP results in increasing differentials in the Pt_d-V LDD between the two orderings; that is, the relative processing

[20] Although for many Pt_i classifications the relevant meaning is spatial, independent particles are not limited to a spatial interpretation: cf. *they turn the radio on*.

[21] McIntyre does not equate his concept of 'construction-specific' meaning with aspectual meaning.

[22] Our definitions of domains are based on two simplifying assumptions: that they are contiguous substrings and that they can be identified by their endpoints.

advantage through minimal domains becomes larger for the joined ordering 13b, so we can expect that particle dependency will play a significant role in particle placement.

(14) Prediction 2 (Pt_d-V LDDs)
Dependency of the particle within a verb-particle phrase will be a significant factor for performance preferences regarding the adjacency of verb and particle. There will be a preference for adjacency if the verb-particle phrase contains a dependent particle.

In addition to the size differences within one particular domain, our predictions must also take into account the interactions between multiple processing domains. The small size of one domain with a specific ordering may come at the price of the larger size of another domain, which can reduce the overall processing advantage. Conversely, a particular ordering can result in several minimal domains, which makes that ordering especially efficient.[23] Since the length of the NP determines the domain-size differentials for both VP PCDs and Pt_d-V LDDs, we predict that the effects formulated in prediction 1 (VP PCDs) and prediction 2 (Pt_d-V LDDs) will reinforce each other, that is, adjacency of verb and particle will be very strongly preferred for phrases that contain a long NP and a dependent particle.

3.3. Testing prediction 2. To test the proposed correlation between particle type and ordering patterns, the corpus data were coded for dependency of the particle (Pt_d/Pt_i) according to the particle entailment test (cf. 11). Since the coding for lexical dependency is less objective than for NP-length, we asked several native speakers for control codings and eliminated a number of cases that proved hard to classify.[24]

The overall split ratios with each particle type confirm our predictions: for verb-particle phrases containing a Pt_d, the split ratio (16%) is significantly lower than for those containing a Pt_i (42%).[25] As Figure 2 shows, the stronger adjacency preference for Pt_d can be observed independently of NP-length. With increasing NP-length the relative advantage of domain minimization increases, especially when two domains can be minimized simultaneously (VP PCD and Pt_d-V LDD). The overwhelming preference for the joined ordering that we expected for long NPs with a dependent particle is strongly supported by the data: only 2 out of 335 of these items (= 0.6%) occur nonadjacent.

[23] For a more detailed discussion of the interaction of multiple processing domains, see Hawkins 2004.

[24] Our control coders agreed in over 80% of all cases with our initial coding. Since we have a large number of items (1,684) and coding instructions that are based on entailment tests that are initially not easy to grasp, especially for nonlinguists, we decided to take a second look at those items where there was disagreement and discuss them in more detail among ourselves and with our control coders. It turned out that many of those cases clustered around specific verbs whose polysemy greatly affects the verb entailment test, which was sometimes overlooked not only by our control coders, but also in our intial coding, for example, (i) *they chopped off his hand* vs. (ii) *they chopped up an onion*. We finally decided to code (i) as V_d and (ii) as V_i. A further source for disagreements was the need to include a number of predication verbs in our formulation of the particle entailment test. We classified a phrase like *they brought up the topic of acid rain* as Pt_d, but, as one of our coders pointed out, it seemed perfectly acceptable to him to say *the topic of acid rain came up*, so it passed the entailment test, although in this case there was no clear notion of spatial *up*. In the end, we made some adjustments to our own intial coding based on the input from our control coders. We also eliminated twelve cases that we considered ambiguous even within their larger context, such as *they picked up a lot of brochures*, where we couldn't decide whether the intended meaning was *lift up from a surface* (*up* = Pt_i) or *come to have* (*up* = Pt_d).

[25] $p < 0.01$. Significance levels were computed with an S-PLUS function provided by Rand Wilcox (p.c.) which tests the hypothesis that two independent binomials have equal probability of success.

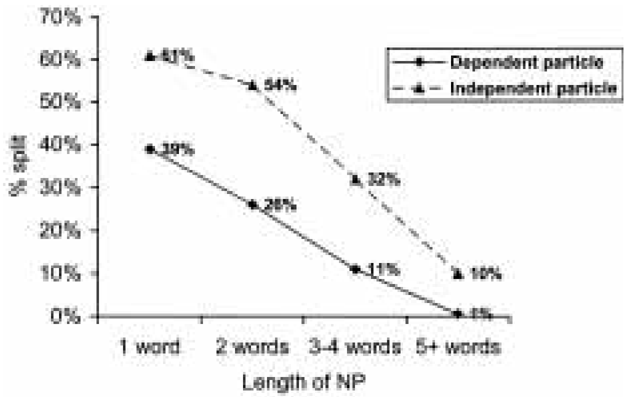

FIGURE 2. Split vs. joined by NP-length and particle type.

3.4. VERB DEPENDENCY DOMAINS AND THEIR PREDICTIONS. The entailment tests discussed in §3.1 provide a classification that captures the different dependency relations between individual verbs and particles. For the processing of verbs it is also necessary to look at lexical-semantic dependencies involving the third category in the verb-particle phrase: the object NP. As Keenan (1978) points out, the interpretation of a transitive verb varies with its object NP. Consider how the precise meaning of *cut* depends on the different objects it is combined with: *cut a cake*, *cut the lawn*, *cut alcohol*, *cut a class*, *cut a film* (Keenan 1978:168–69). This kind of semantic reduction can also be observed with intransitive verbs in relation to their subjects: *the car is running* vs. *the faucet is running*; and with adjectives in relation to the noun they modify: *a flat road* vs. *a flat beer* (1978:168–69). As Keenan shows, the semantic dependencies observed here correspond closely to agreement patterns found across languages.

The semantic reduction function of the object NP is also apparent in our entailment test for dependent verbs. Due to the polysemy of many simple as well as particle verbs, a full noun is usually required to determine the entailment relations. It is impossible to decide whether *they wrapped it up* entails *they wrapped it* without knowing the reference of *it*. When a full noun is used, the entailment is clear: for *the parcel* the entailment goes through; for *the meeting* (i.e. *they wrapped up the meeting*) it does not. This dependency between verb and object NP holds regardless of the classification of the verb as dependent (on the particle) or independent and regardless of the classification of the particle. There is also experimental evidence that further supports the central role of the NP. Findings from studies on split particle verbs in Dutch (Zwitserlood et al. 1996) and German (Drews et al. 1999) indicate that the exact semantic relationship between particle verbs and their simplex counterparts does not start to affect the processing of the verb until certain semantic clues within the object NP are encountered.

Based on the dependency relations between verb and particle on the one hand, and verb and object NP on the other hand, we can now define lexical dependency domains for each verb type.[26] Here—in contrast to VP PCDs and Pt_d-V LDDs—it is not only the length of the NP but also its internal structure that affects domain size. Since the object NP can consist of multiple words, the exact endpoint of the dependency domain

[26] The subtypes, as indicated by the subscripts $_d$ and $_i$, reflect only dependency between verb and particle. Dependencies on the object NP are not indicated by subscripts.

needs to be specified as the head noun of the NP. It is the head that carries the relevant information for property assignment to the verb. Access to a determiner or modifier usually cannot provide that information.

(15) V_d-(N; Pt) lexical dependency domain (V_d-(N; Pt) LDD)
The LDD for a DEPENDENT VERB (V_d) consists of the smallest contiguous substring that contains the V_d, the particle, and the head noun of the object NP on which the V_d and Pt depend for semantic and/or syntactic property assignments.

(16) V_i-N lexical dependency domain (V_i-N LDD)
The LDD for an INDEPENDENT VERB (V_i) consists of the smallest contiguous substring that contains the V_i and the head noun of the object NP on which the V_i depends for semantic and/or syntactic property assignments.

Whereas NP-length and particle dependency are expected to be significant factors for ordering preferences, verb dependency is predicted here not to be significant in most cases. The placement of the particle does not usually affect the size of the V_d-(N; Pt) LDD. Both orderings (17a and 17b) result in identical domain sizes, independently of NP-length, as long as the head noun occurs at the right periphery of the object NP, which is the case in over 85% of our corpus data.[27]

(17) a. pick$_d$ $_{NP}$[the heavy boxes] up
V_d-(N; Pt) LDD 1 2 3 4 5
b. pick$_d$ up $_{NP}$[the heavy boxes]
V_d-(N; Pt) LDD 1 2 3 4 5

For independent verbs, there is a slight relative processing advantage for the split construction, in which the particle occurs outside the V_i-N LDD.

(18) a. lift$_i$ $_{NP}$[the heavy boxes] up
VP PCD 1 2 3 4 5
V_i-N LDD 1 2 3 4
b. lift$_i$ up $_{NP}$[the heavy boxes]
VP PCD 1 2 3
V_i-N LDD 1 2 3 4 5

In the joined construction 18b, the particle increases the size of the V_i-N LDD. The added cost of this one (short) word remains constant, independently of the length of the NP. A one-word differential is not likely to result in an ordering preference in this case. The LDD difference between 18a and 18b is small, and in addition the minimization benefit of 18a for the V_i-N LDD is counteracted by the VP PCD minimization effect in 18b, which increases as the NP becomes longer.[28] The structure in 18a results in a V_i-N LDD shorter by one word, while that in 18b results in a VP PCD shorter by two words. There should not be a significant preference for one particle ordering over the other with independent verbs, nor will there generally be one with dependent verbs.

(19) Prediction 3 (V_d-(N; Pt) LDDs/V_i-N LDDs)
Dependency of the verb within a verb-particle phrase will not generally be a significant factor for performance preferences regarding the adjacency of verb and particle.

[27] Cases where the NP contains postnominal material are considered at a later point.

[28] One question that immediately arises in this context of competing domains is whether both of these domains have equal costs associated with them. Although we assume equal costs as a working hypothesis, our model does not depend on this assumption.

3.5. Testing prediction 3. To test the overall significance of the factors proposed so far, we entered them in a loglinear analysis.[29] The prediction was that NP-length and particle dependency would be significant with regard to particle placement as indicators of domain-minimization effects (VP PCDs and Pt_d-V LDDs). Verb dependency, by contrast, would not be significant. The data were coded for NP-length (measured in number of words), for dependency of the particle (Pt_i/Pt_d), for dependency of the verb (V_i/V_d) according to the respective entailment tests, and for corpus/register.[30] The data confirm that NP-length is indeed highly significant ($\chi^2(3) = 218.58$, $p < 0.001$). The same holds for particle dependency ($\chi^2(1) = 108.23$, $p < 0.001$). As expected, verb dependency is not a significant factor ($\chi^2(1) = 0.59$, $p = 0.44$). Finally, corpus also came out as significant ($\chi^2(1) = 10.99$, $p < 0.001$).

As Figure 3 shows, dependent and independent verbs display identical split ratios (26%), in contrast to the significant difference in split ratios between dependent and independent particles.

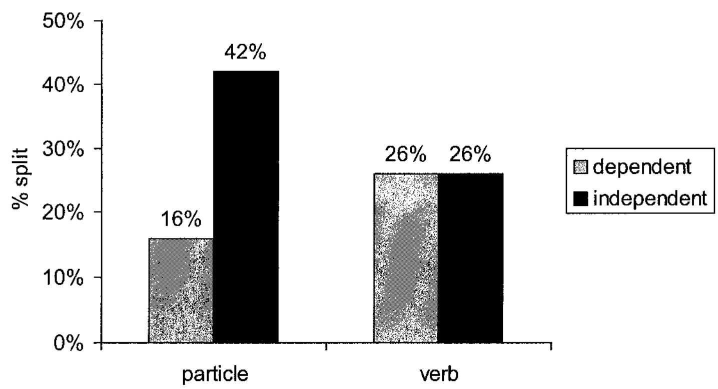

Figure 3. Split vs. joined by particle and verb dependency.

4. The location of the head noun within the object NP and its effects on particle placement. So far we have focused on dependencies between verb and particle and between verb (plus particle) and object NP. A final dependency relation to consider is between particle and object NP. A possible dependency of Pt_d on the NP is essentially preempted by its dependency on the verb: The particle is part of a complex verb and V must first be accessed if Pt_d is to be recognized as part of this complex and if properties appropriate to the complex are to be assigned to it. The whole complex verb then may or may not be dependent on the object NP. A particle classified as Pt_i by the particle entailment test (11), by contrast, can be assigned a meaning that

[29] Like ANOVA, a loglinear analysis allows examination of the relationship between categorical variables. Of particular interest to us was its partial chi-square statistic that provides a test for the hypothesis that an effect is 0, as well as an indication of the relative importance of each effect. All loglinear analyses were performed using SPSS 9.0.

[30] Like particle dependency, the verb dependency classifications were subject to several control codings to decrease subjectivity.

can occur outside the verb-particle phrase. The only possible interpretation of *the dishes* *ARE up* is a spatial sense of *up* (i.e. as Pt$_i$: *they brought up the dishes*); the perfective meaning of *up* (i.e. as Pt$_d$: *they washed up the dishes*) requires access to the verb.[31]

For independent particles it is the object NP alone, therefore, that provides information of relevance for the meaning of the particle. Compare the different interpretations of *on* in *put the hat on* vs. *turn the radio on*: the particle is semantically independent of the verb in both cases (i.e. *the hat IS on* and *the radio IS on* are entailed), but it has entirely different meanings.

(20) Pt$_i$-N lexical dependency domain (Pt$_i$-N LDD)
The LDD for an INDEPENDENT PARTICLE (Pt$_i$) consists of the smallest contiguous substring that contains the Pt$_i$ and the head noun of the object NP on which the Pt$_i$ depends for semantic and/or syntactic property assignments.

The split ratios for verb-particle phrases with independent particles in Fig. 2 (§3.3) provide only limited evidence for the reality of a Pt$_i$-N LDD. The endpoints for this domain are the Pt$_i$ and the head noun of the object NP. Since the head noun usually occurs at the right periphery of the NP, in most cases the split ordering (V $_{NP}$[. . . N] Pt$_i$) will result in a smaller Pt$_i$-N LDD than the joined ordering (V Pt$_i$ $_{NP}$[. . . N]). This minimization effect will compete, however, with the VP PCD minimization effect. In the split order, the PCD becomes less efficient with increasing length of the NP, while the Pt$_i$-N LDD becomes more efficient. Examples 21a and 21b compare the domain sizes in both orderings to illustrate the competing effects.

(21) a.

	pick	$_{NP}$[the	very	heavy	boxes]	up$_i$
VP PCD	1	2	3	4	5	6
Pt$_i$-N LDD					1	2

b.

	pick	up$_i$	$_{NP}$[the	very	heavy	boxes]
VP PCD	1	2	3			
Pt$_i$-N LDD		1	2	3	4	5

Notice how their collective effect results in equal domain minimization. The structure in 21a reduces the Pt$_i$-N LDD size by three words, but increases the VP PCD size by three words, and vice versa in 21b. This pattern holds independently of NP-length, with the result that the two minimization effects work consistently against each other. If there is indeed a Pt$_i$-N LDD minimization effect in these cases, it will be outweighed by the VP PCD minimization effect, as long as the head noun appears in final position within the object NP.

Evidence for a Pt$_i$-N LDD effect can be found in those cases where the head noun does not occur as the rightmost element, that is, with object NPs that contain postnominal material like relative clauses or prepositional phrases. The presence of postnominal material can affect the exact size of the Pt$_i$-N LDD. The split ordering in 21a results in a minimal LDD because the head noun is immediately adjacent to the particle. In 22a and 22b, by contrast, the NP contains a postnominal relative clause, and it is now

[31] As discussed in the next paragraph, the interpretation of *up* also depends on the particular object NP. An interpretation of *up* as Pt$_i$ is not limited to a spatial one. Nonspatial, temporal readings are, for example, possible with *time IS up* or *the jig IS up*. The perfective reading of *up* in *they washed up the dishes*, however, can be assigned only in combination with the verb *wash*. Similarly, a phrase like *he gave up his time* is classified as Pt$_d$ since it does not entail *his time IS up*.

the joined ordering 22b that results in a shorter LDD. There is also no longer any competition between the VP PCD and the Pt_i-N LDD; 22b minimizes both.

(22) a.

	pick	$_{NP}$[the	boxes	I	found]	up_i
VP PCD	1	2	3	4	5	6
Pt_i-N LDD			1	2	3	4

b.

	pick	up_i	$_{NP}$[the	boxes	I	found]
VP PCD	1	2	3			
Pt_i-N LDD		1	2	3		

The possible relevance of a Pt_i-N LDD should, therefore, be visible in a comparison between object NPs with postnominal material and those with only prenominal material. We predict that the split ratio with object NPs containing postnominal material will be considerably lower than with NPs of comparable length that contain only prenominal material. One has to keep in mind, however, that NPs with postnominal material are always of considerable length, so we have to expect a strong VP PCD minimization effect in favor of the joined order.[32]

To test our hypothesis, we extracted those NPs from our database that were long enough to contain postnominal material ($\geq$ 4 words[33]), and at the same time, short enough to actually still occur in the split construction ($\leq$ 8). We also had to control for structural correlations with length. For NPs longer than six words, only very few lack postnominal material, which means that the head occurs predominantly to the left, and proposed correlations with variable head positioning could not be tested. We therefore limited the subset for testing to NPs of four to six words ($n = 326$).

Within this subset, the overall split ratio is significantly lower for NPs with postnominal material (6%) than for those with prenominal material only (19%; $p < 0.01$). This result is consistent with our prediction of a strong VP PCD minimization effect due to a more complex NP-internal structure. In the split construction, where phrase combination takes place over the entire NP, this added complexity will result in higher processing costs, and adjacency between verb and particle has, therefore, a greater relative processing advantage.[34] As Figure 4 shows, the split ratio for verb-particle phrases containing an independent particle and an NP with postnominal material is indeed lower than for those with prenominal material only. The difference in split ratios (30% vs. 15%) is only marginally significant ($p = 0.052$), but it reaches significance once we limit the group of NPs with postnominal material to those where the head noun actually occurs closer to the beginning of the NP than to its end (30% vs. 13%; $p < 0.05$).

The Pt_i-N LDD will be shorter in the joined ordering than in the split only if the prenominal string is shorter than the postnominal string. These results provide evidence that the exact location of the head noun affects particle placement through domain-minimization effects.

The data subset described above also allows us a more detailed investigation of verb dependency effects. As discussed earlier (see 17a and 17b, repeated below), the placement of the particle does not affect the size of the V_d-(N; Pt) LDD, as long as the head noun occurs at the right periphery of the object NP.

[32] In addition, postnominal material usually increases the complexity of the NP, which can also affect preferences in favor of adjacency of verb and particle (Hawkins 1994:69–72, Gries 2003).

[33] In our data, less than 2% of all three-word NPs contained postnominal material.

[34] Hawkins's principle of EIC, the metric that underlies PCDs, was explicitly designed to account for length as well as complexity effects (cf. Hawkins 1994:69–71).

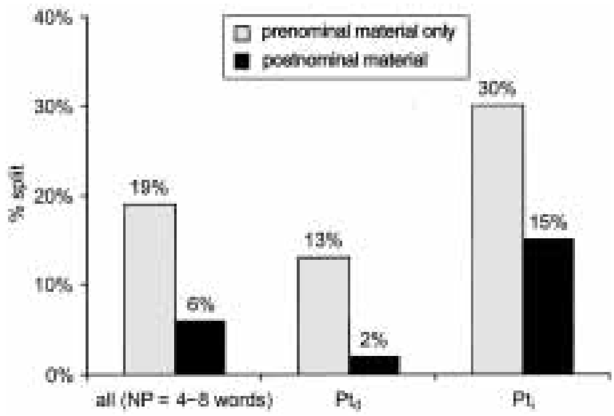

FIGURE 4. Split vs. joined by internal NP structure and particle dependency.

(17) a. pick$_d$ $_{NP}$[the heavy boxes] up
V_d-(N; Pt) LDD 1 2 3 4 5
b. pick$_d$ up $_{NP}$[the heavy boxes]
V_d-(N; Pt) LDD 1 2 3 4 5
(23) a. pick$_d$ $_{NP}$[the boxes I found] up
V_d-(N; Pt) LDD 1 2 3 4 5 6
b. pick$_d$ up $_{NP}$[the boxes I found]
V_d-(N; Pt) LDD 1 2 3 4

If, however, the object NP contains postnominal material, the joined ordering in 23b results in a shorter LDD than the split ordering in 23a, and we may be able to observe an adjacency preference of verb and particle for those phrases that contain a dependent verb and an object NP with postnominal material.

For independent verbs, the exact location of the head noun within the NP does not significantly affect the difference in the size of the V_i-N LDD between the two orderings. In 18a and 18b (repeated below) as well as in 24a and 24b, the domain-size differential is one word, namely the particle, so that we do not expect any observable differences in the split ratios between NPs with postnominal material and those with only prenominal material.

(18) a. lift$_i$ $_{NP}$[the heavy boxes] up
V_i-N LDD 1 2 3 4
b. lift$_i$ up $_{NP}$[the heavy boxes]
V_i-N LDD 1 2 3 4 5
(24) a. lift$_i$ $_{NP}$[the boxes I found] up
V_i-N LDD 1 2 3
b. lift$_i$ up $_{NP}$[the boxes I found]
V_i-N LDD 1 2 3 4

Looking at just those NPs with postnominal material in our data subset, the split ratios for dependent verbs (4%) and independent verbs (11%) do not differ significantly. These low percentages are, however, at least partially due to the extremely low split ratio for dependent particles and NPs with postnominal material (2%; cf. Fig. 4).[35]

[35] The low split ratio here is not surprising, given that two domains (whose minimization effects have been shown to be very robust) are minimized in the joined ordering: the VP PCD and the Pt_d-V LDD.

Figure 5 compares the split ratios for the two NP types across all four possible verb-particle combinations. For V_d Pt_i and V_i Pt_i, the very strong adjacency preference of Pt_d is eliminated, and the numbers confirm our predictions. V_d Pt_i and V_i Pt_i behave very similarly for NPs with prenominal material only (29% vs. 33%), but differ significantly ($p < 0.05$) with NPs containing postnominal material (9% vs. 29%), supporting the proposed relevance of the exact location of the head noun as the potential endpoint of the V_d-(N; Pt) LDD. As expected, particle placement for V_i Pt_i is not significantly affected by the location of the head noun (33% vs. 29%), while the split ratio for V_d Pt_i is clearly lower for NPs with postnominal material (9%) than for those with prenominal material only (29%), with at least marginal significance ($p = 0.054$).

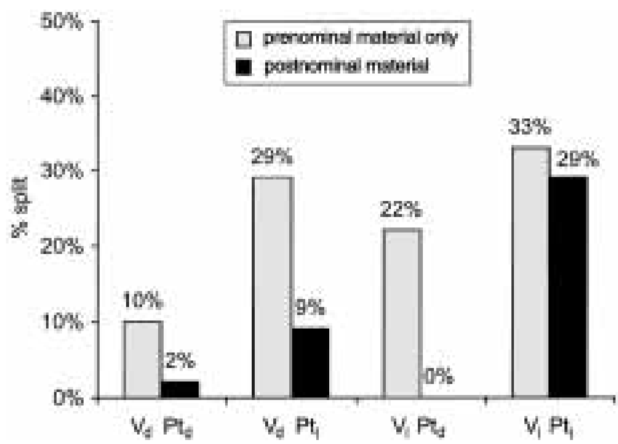

FIGURE 5. Split vs. joined by internal NP structure and verb-particle combination.

With regard to the location of the NP head noun, domain minimization makes rather subtle predictions. Even though they apply only to a relatively small subset of the data, the predictions could be confirmed and provide further support for the relevance of the processing domains we have defined.

5. DISCUSSION. Overall, we have proposed five processing domains: VP PCD, Pt_d-V LDD, Pt_i-N LDD, V_d-(N; Pt) LDD, and V_i-N LDD. The data provide evidence for domain-minimization effects for all but the V_i-N LDD. The relative strengths of these effects in predicting particle placement can be explained through the relative processing advantage of one ordering over the other within each domain and through the interactions between domains. Since minimizations can compete with each other, some effects are harder to detect. As we pointed out, the Pt_i-N LDD (preferring nonadjacency of verb and particle when the head noun is final within NP) is usually in conflict with the VP PCD (preferring adjacency of verb and particle), so that minimization in the former may be observable only in a specific subset of the data, where the competition is neutralized. Such limited visibility allows for alternative interpretations. The actual role of the Pt_i-N LDD, however, is not central to our proposal.

There is also the possibility that other processing domains may affect the relative strengths of the minimization effects we propose in this article. Dependency relations between transitive verbs and direct objects are not limited to those discussed in §3.4. While a transitive verb depends on the direct object for its precise interpretation, the direct object in turn depends on the verb for its theta-role assignment. Multiple dependency relations between verb and direct object can account for the crosslinguistic adjacency patterns that underlie Tomlin's (1986) verb-object bonding principle.[36] Both V_d-(N; Pt) LDD and V_i-N LDD may, therefore, represent more than one processing domain. In the competition between the V_i-N LDD and the VP PCD, the crucial aspect in favor of the VP PCD is that a minimal PCD (i.e. a joined ordering) always results in a V_i-N LDD that is nonminimal by only one word, the particle. A minimal LDD, by contrast, can result in a very long VP PCD, depending on the length of the object NP. If we consider the particle as a single word of a larger phrase, the length of that phrase may affect ordering preferences based on V_i-N LDD minimization. So it is not the length of the object NP per se that drives ordering patterns, but rather the difference in length between the object NP and the particle phrase. These aspects cannot be analyzed based on our corpus data, since our database is limited to single-word particle phrases.

A further point to consider is the choice of tools to establish and measure the relevant processing domains. Our entailment tests for verbs and particles force a binary coding, but one has to assume that verb and particle dependency is ultimately a graded concept, for which a binary opposition can only be an approximation.[37] As discussed earlier, even within the group of verb-particle phrases for which we can establish a Pt_d-V LDD, we have to assume the possibility of different degrees of lexical dependency that may affect the actual domain-minimization effect. A similar issue becomes apparent with regard to measuring actual domain sizes. They are measured in words as a convenient and effective approximation of the amount of material the processor needs in order to construct all three constituents of the verb-particle phrase, and also to assign semantic and syntactic properties to dependent categories. An obvious measurement alternative is the number of syllables as in Chen 1986. Gries (2003) codes for both number of syllables and number of words. He finds that both measurements yield very similar and highly informative results, although in his analysis the number of syllables appears to be a slightly better predictor for the choice of ordering. But since Gries does not apply permutability as a coding criterion, his database includes many verb-particle phrases with personal pronouns as (one-syllable) object NPs, and this, unfortunately, makes his finding less conclusive.[38]

One finding that our measurements do not capture at this point concerns the split ratios for one-word NPs. Unstressed personal pronouns occur almost exclusively in the split construction, whereas fully lexical nouns display a fairly low split rate of 35%. These two groups appear to represent the opposite ends of a scale. Demonstrative, possessive, and reflexive pronouns are very close to the unstressed personal pronouns with 94% split constructions. Indefinite pronouns like *somebody* or *anything* and referentially vague nouns like *things* or *people* are still considerably skewed in favor of a higher split ratio (76%), but not as strongly as the definite pronominals.[39] Dependency of the particle is a relevant predictor only for fully lexical one-word NPs; the more pronominal ones show no difference in split ratios according to particle type. These results can be interpreted as reflecting differences in processing cost associated with each type of NP based on referentiality. It remains to be seen whether and how such

[36] For a more detailed discussion of the multiple dependency relations between verbs and direct objects, see Hawkins 2004.

[37] Cf. our discussion in §3.1 and a similar comment by Aarts (1992).

[38] For a more extensive discussion of possible measurements of weight, including questions of purely prosodic measurements and length vs. complexity, see Hawkins 1994, Wasow 2002, Rickford et al. 1995, and Green 2004.

[39] See Gries 2003 for similar results.

differences can be integrated into the general principle of minimize domains. In Gibson's (1998) complexity metric, which is in many respects similar to Hawkins's EIC, the crucial units for measurement are new discourse referents. Gibson's metric is based on the premise that individual words, especially nouns, may contribute different amounts of cost to a processing domain.

In contrast to Hawkins's earlier work (1994) and to Gibson (1998), Hawkins (2004) proposes an explanation for word-order preferences that does not appeal primarily to working memory capacity. In fact, he shows that some preferences are associated with an increase, not a decrease, in working memory load as Gibson defines it, and that we need a multifactor and more broadly based explanation for ordering preferences, including domain-minimization effects.[40]

The results of our statistical analysis of the corpus data match those presented by Gries (2003) in several respects. In his ranking of factors according to their relative strength, three of the top five—complexity of the direct object, length of the direct object, and idiomaticity—are closely correlated to the two factors we have focused on, NP-length and particle/verb dependency. Furthermore, he also stresses that the individual values of these factors are not equally good predictors for the choice of ordering (Gries 2003:106). If an NP is complex and/or long, there is a strong preference for a joined construction, but with a short and/or simple NP, the preference for a split is not quite as strong. Gries's data show, just like ours, that the actual turning point between preferences (from split to joined) is an NP-length of three words (Gries 2003:84). A similar asymmetry in prediction strength can be found for the level of idiomaticity. Highly idiomatic particle verbs prefer a joined ordering, but there is not an equally strong preference for a split ordering with literal particle verbs (Gries 2003:106). Particle dependency does not entirely correspond to idiomaticity. Although a dependent particle usually reflects a high degree of idiomaticity, this is not always the case (cf. *wash up*). But we also find that a dependent particle is a better predictor for the joined construction than an independent one is for the split. A direct comparison of our results with Gries's is not entirely useful, since there are important differences in the selection criteria, in the factors considered, and in the coding of the level of semantic compositionality.

The main difference between the studies lies in the explanatory approach. Gries attempts to subsume all factors under his 'processing hypothesis', which is stated in very general terms: Particle placement is determined by the amount of processing effort that the object NP requires. If the amount is low, the preferred ordering is split; for high amounts it is joined (Gries 2003:48). Consequently, he has to link each individual variable with a particular processing cost. For NP-length and complexity, Gries states that the processing efforts linked with short/simple vs. long/complex NPs are self-evidently low and high respectively. Furthermore, following Quirk et al. 1985, he argues that new information is usually encoded using more material, leading to longer/more complex NPs and more processing effort (Gries 2003:57).

Domain minimization, by contrast, allows us to formulate the link between processing cost and ordering preferences more precisely. The preference (80%) for the split construction with one-word object NPs in Gries's data includes cases with pronouns as object NP (Gries 2003:84). Since the split is basically the only option in these cases, these figures do not necessarily reflect a performance preference. In our database, permutability was made a selection criterion so as to ensure that there is indeed a choice between orderings for each individual item, and personal pronouns as object NPs were

[40] See Hawkins 2004 for details.

consequently excluded. Our data show a split ratio of only 46% for one-word object NPs and no clear preference for a split construction. Based on phrasal-combination domains, both the joined and the split ordering are actually equally efficient for one-word NPs, so the lack of an ordering preference is to be expected. Domain minimization provides an explanation for why a long NP is a more powerful predictor than a short NP, and for why the degree of preference for the joined order rises with increasing NP-length.

As Gries himself points out (Gries 2003:54), domain minimization for lexical dependencies also predicts that a high degree of idiomaticity is a stronger predictor for ordering preferences than a low degree. A dependency domain between verb and dependent particle leads to a difference in processing cost between joined and split orderings, which results in a performance preference for the joined ordering. In the absence of such a dependency domain between verb and independent particles, no clear preferences are to be expected, even if a Pt_i-N LDD is considered.[41] Our data confirm these results. We could not replicate Gries's finding of a preference (72%) for the split construction with literal/spatial meaning (Gries 2003:87). Following his coding criteria (Gries 2003: 71–72), our data showed a split ratio of only 42%, that is, no clear preference for either construction. This lower percentage is not inconsistent with Gries's argument that the split ordering underscores the literal meaning since the particle occurs in end-focus (Gries 2003:52). The semantic contribution of an independently processable particle makes it a more suitable candidate for end-focus than a dependent particle would be. This should result in a higher split ratio for independent particles compared to dependent particles, but not necessarily in a preference for independent particles to occur in end-focus.[42]

[41] As we discussed in §4, a possible Pt_i-N LDD minimization effect in form of a preference for the split ordering is counteracted by the VP PCD minimization effect. Those cases where the internal structure of the object NP leads to a shorter Pt_i-N LDD in the joined ordering are not frequent enough to result in clear overall ordering preferences.

[42] The fact that we could not confirm a preference for the split construction with particles in their literal meaning also raises questions about Gries's discussion of semantic modification of the particle (as in e.g. *they brought the chairs right up*). Our corpus data revealed only very few instances of semantic modification, but as Fraser (1976) observes, the presence of a modifier restricts the choice of ordering. A semantically modified particle can occur only in the split construction. Gries (2003:55) proposes that it is the correlation with the level of idiomaticity of the verb-particle phrase that accounts for this restriction since only particles that are used in their literal sense can be modified (Dirven & Radden 1977). Within our classification, modification is limited to those particles that are independently processable, which makes them more appropriate candidates for modification than dependent particles. Independent particles in our data, however, occur quite frequently (58%) in the joined ordering, but only the presence of a sufficiently long and/or complex NP makes modification of an independent particle in that ordering acceptable (cf. **they brought right up the chairs* vs. *they brought right up those chairs that had previously been reserved for only very special occasions*). A possible explanation lies in the combinatorial and dependency relations between transitive verbs and direct objects. In English, a minimal processing domain for these relations is consistently preferred or even conventionalized (cf. **we saw yesterday the boy*). In cases of Heavy-NP Shift, the phrasal combination domain of the entire VP (V; PP; NP) is usually sufficiently minimized to compensate for the nonadjacency of transitive verb and direct object (cf. also Hawkins 1994, 2001, 2004 and Wasow 1997, 2002). Similarly, an increase in the size of the V_i-N LDD in a joined ordering is tolerated as long as the particle phrase consists of just one (short) word, namely the particle, especially if there is a considerable minimization of the VP PCD (cf. our discussion in §3.4). With the modification of the particle, the joined ordering becomes more costly for the V_i-N LDD—a domain that is frequently minimal in English—and has to be justified by a sufficiently large processing advantage for the VP PCD, that is, a sufficiently heavy direct object NP. The reason for the restriction of modified particles to the split construction may therefore lie in the interaction between competing processing domains rather than simply in the correlation with the level of idiomaticity of the verb-particle phrase.

The comparison by register, that is, looking at the three written corpora vs. Switchboard, also raises some interesting issues. Although, on average, NPs in the written data are one word longer than in the spoken data and the percentage of complex NPs longer than four words is significantly higher, there is no significant difference in the distribution of dependent and independent particles. Figure 6 shows that the registers differ with regard to the PCD minimization effect. While the registers behave very similarly for NPs shorter than three words, the split ratios for NPs longer than two words in the written data decrease significantly more steeply than for the spoken data.

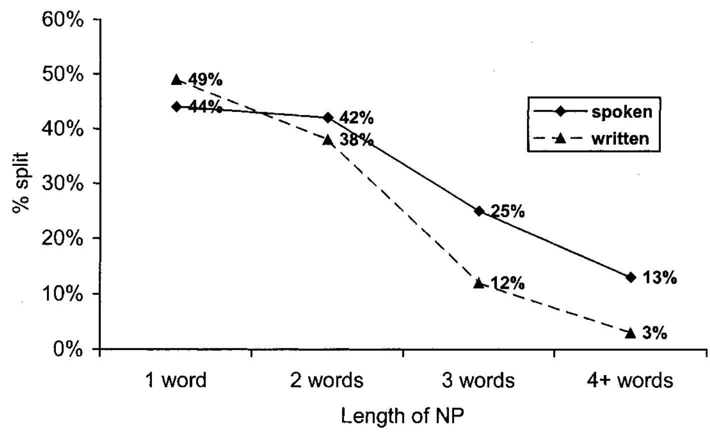

FIGURE 6. Split vs. joined by NP-length and register.

The same holds true for the particle-dependency effect (Figure 7). Again, there is a much steeper decline in split ratios for the written data, especially for independent particles. These findings suggest that, although both main factors (NP-length and particle dependency) are highly significant independent of register, they exert a stronger influence in the written data. In speech, planning and production impose constraints that sometimes are in conflict with those imposed by the parser. In writing, especially edited writing, the temporal constraints on production are largely removed, so the needs of the parser can be given more weight and domain minimization becomes more visible.

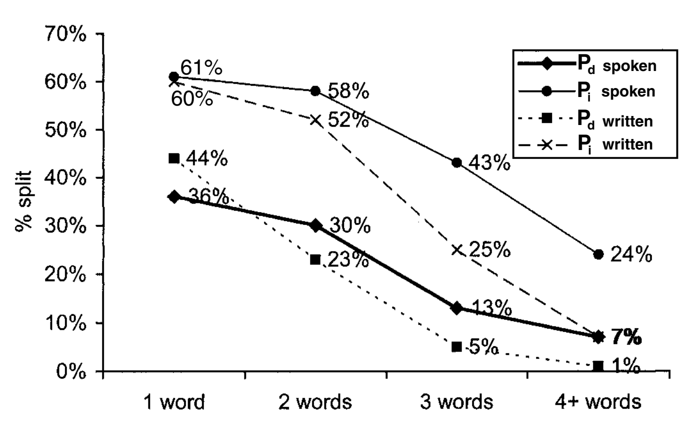

FIGURE 7. Split vs. joined by NP-length, particle type, and register.

6. Conclusion. Minimize domains is a general principle of processing efficiency and complexity that can account for syntactic variation in performance crosslinguistically (Hawkins 2001, 2003, 2004). We have shown that it subsumes major syntactic and semantic factors that contribute to particle placement and allows a precise formulation of how these factors are linked to processing cost, based on one unified theoretical principle. It also accounts for Gries's (2003) statistical observation that within these factors, individual values differ with regard to their relative strength, and it makes some new predictions that Gries did not consider. Although we did not consider discourse variables in this study, they can, in principle, be built in as additional predictors to achieve an even more fine-tuned account of the performance preferences.

Appendix: Classification examples for verb dependency and particle dependency

The following list gives examples from our database for each of the possible verb-particle combinations:

V_i Pt_i
- Bring in her own chair and TV set
- Flung their rifles up
- Gulped down the whiskey
- Pumping out the water
- Shaved the beard off

V_i Pt_d
- Call parents up
- Cash in their toy portfolio
- Finished up her Bachelor's degree
- Kill off a few of them
- Washed the brushes out

V_d Pt_i
- Turn off the lights
- Letting large numbers of Haitians in
- Putting out great big huge garbage cans
- Slipped my coat on
- Wheeled in breakfast

V_d Pt_d
- Carries out the captive's plan
- Messed up the conversation
- Nailed the problem down
- Rip off this guy
- Turns people off

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Lohse
Schillingstr. 27a
44139 Dortmund
Germany
[lohse@usc.edu]

Hawkins
Department of Linguistics
Grace Ford Salvatori 301
University of Southern California
Los Angeles, CA 90089-1693
[hawkins@usc.edu]

Wasow
Department of Linguistics
Stanford University
Stanford, CA 94305-2150
[wasow@csli.stanford.edu]

[Received 5 May 2003;
accepted 14 September 2003]