Covarying collexemes*

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Abstract

Adopting the perspective of construction grammar and related frameworks, this paper introduces a corpus-based method for investigating correlations between lexical items occurring in two different slots of a grammatical construction. On the basis of three case studies dealing with the into-*causative, English possessive constructions, and the way-construction, we show that such correlations are determined by semantic coherence. We identify three kinds of coherence: one based on frame-semantic knowledge, one based on semantic prototypes, and one based on image schemas. We conclude by proposing a method that can potentially enhance the precision of our results and that allows us to identify ever-finer contrasts by adopting a multidimensional perspective towards co-occurrence patterns.*

Keywords: *construction grammar; collostructional analysis; covarying collexemes; Fisher-Yates exact test; configural frequency analysis.*

1. Introduction

When investigating the relationship between words and grammatical structures, researchers typically focus on the preferences or restrictions associated with individual slots in the construction; little attention is paid to possible interactions between two (or more) such slots. However, such interactions are intuitively important at least for some constructions, which have several semantically or pragmatically constrained slots, for example, the *into*-causative (*He* TRICKED *me into* EMPLOYING *him*), 'genitive' constructions (*JOHN's BOOK*, PART *of the* PROBLEM), the *way*-construction (*He* FOUND *his way* TO *New York*), and many others.

In previous work, we have proposed corpus-based methods for investigating the association between a given construction and the words occurring in a particular slot provided by it, either in relation to the language as a whole (Stefanowitsch and Gries 2003), or in relation to some

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semantically or functionally near-equivalent construction (Gries and Stefanowitsch 2004a). In this work we have shown, among other things, that such associations are based on the degree of semantic compatibility between the meaning of the construction and that of the word. In this paper, we extend these methods to the investigation of potential interactions between (sets of) words occurring in two different slots of the same construction (cf. also Gries and Stefanowitsch 2004b), and apply it to the cases just mentioned. We show that there are constraints holding between different slots of a construction (i. e., that words in such slots may covary systematically) and that these constraints are based on semantic coherence. Specifically, we show that this semantic coherence may be based on different criteria and identify three main types.

This paper is structured as follows. Section 2 discusses the theoretical and methodological prerequisites underlying our approach and briefly summarizes our previous work on collostructional analysis. Section 3 introduces the new method, which we refer to as *covarying-collexeme analysis*. In Section 4, we present three case studies and discuss different types of semantic coherence. In Section 5, we then discuss possible refinements and corrections concerning the basic method.

2. Collostructional analysis

2.1. Theoretical and methodological prerequisites

Collostructional analysis (Stefanowitsch and Gries 2003; Gries and Stefanowitsch 2004a, b) has grown out of a merger of two currents in modern linguistics, one theoretical and one methodological. The theoretical current is made up of a broad range of modern syntactic theories that view (at least some) syntactic structures as meaningful elements and that we will call − simplifying vastly − *constructional* theories. The methodological current is that of corpus linguistics, more specifically, of what we call *quantitative corpus linguistics* (cf. Gries and Wulff, to appear; Stefanowitsch, to appear a, b).

Let us begin with the theoretical current. Traditional approaches view the lexicon and the grammar of a language as qualitatively completely different phenomena: the lexicon is seen as consisting of linguistic signs (form-meaning pairs), and the grammar as consisting of abstract (and meaningless) syntactic rules. In contrast, constructional approaches view both lexicon and (at least some of) grammar as consisting of meaningful units, and hence of linguistic signs − most conspicuously, the group of theories known as ‘construction grammars’ (cf. e. g., Fillmore 1988; Fillmore and Kay 1995; Lakoff 1987; Goldberg 1995, 1999), but also other theories, such as Systemic Functional Grammar (Halliday 1985), Emergent Grammar (Hopper 1987), Cognitive Grammar (Langacker 1987; cf. also Croft's [2001] version of Cognitive Grammar, which he refers to as Radical Construction Grammar), some versions of Lexical-Functional Grammar (cf. Pinker 1989), and some versions of Head-driven Phrase Structure Grammar (cf. Sag, Wasow, and Bender 2003).

In this paper, as in our previous work, we will adopt the terminology and basic assumptions of construction grammars, but the method we develop below and the results it yields are, in our view, potentially relevant to all theoretical frameworks just mentioned. Even within the family of construction grammars, however, there are quite drastic differences concerning explicit or implicit fundamental assumptions. One of these differences is the one between what we will call *strict* vs. *loose* constructionality, and this difference will play a role at various points in this paper. Strict constructionality refers to a view where every linguistic unit – morphemes, lexemes, fixed or flexible multi-word expressions, and grammatical structures – are seen as constructions on an equal footing. Loose constructionality, in contrast, refers to a view that accords an elevated status to grammatical structures and (some) multi-word expressions, and that views morphemes, words, and at least some multi-word expressions as subordinate in some sense.

To illustrate this difference, take an utterance like *John threw Mary a ball*. Under a strictly constructional interpretation, this utterance would manifest (roughly) 11 constructions: the subject-predicate construction, a verb-phrase construction licensing two direct objects, two types of noun-phrase constructions (one with and one without a determiner), the 'ditransitive' argument-structure construction, the past-tense construction, and the five lexical items. Under a loosely constructional interpretation, this utterance would manifest as little as one construction, the ditransitive construction, which provides both the argument structure and the grammatical relations (and/or the 'tree'), and five words that have been inserted into the slots provided by this construction (the status of tense and similar phenomena under such an interpretation would be unclear).

As mentioned above, and regardless of whether a strictly or a loosely constructional approach is adopted, grammatical structures are assumed to be meaningful. This idea can also be demonstrated using the utterance just mentioned, *John threw Mary a ball*. This utterance can be roughly paraphrased as 'John caused Mary to receive a ball by propelling the ball with force through the air such that Mary was able to catch it'. The question is where the 'cause to receive' meaning comes from: it is not part of the meaning of the verb *throw*, which simply means 'propel through the air with force', and none of the other lexical items can plausibly be argued to contribute it either. A lexicalist solution might posit an additional lexical entry *throw*$_2$/'cause to receive by propelling with force through the air'. However, there are countless verbs that do not have a 'cause to receive' meaning in their basic use but take on such a meaning when used with ditransitive syntax, and positing additional lexical entries for all of them would lead to an inflation of the lexicon while at the same time missing the generalization that ditransitive syntax and the meaning 'cause to receive' are linked somehow. A constructionist solution to this problem is to argue that the grammatical structure [SUBJ V OBJ_1 OBJ_2] itself (or rather, an abstract representation of it that would accommodate different voices, moods, and word orders) contributes this meaning, and maps it onto any verb occurring in it. This avoids a seemingly arbitrary proliferation of lexical entries.[1] Of course, the question arises as to how the co-occurrence of particular words with particular constructions is constrained, for example, what determines which verbs can (or are likely to) occur with ditransitive syntax, and which cannot (or are unlikely to). This is an issue of considerable complexity (cf. Goldberg 1995: Chapter 2; Pinker 1989). One basic constraint, however, is what we might call the *Principle of Semantic Compatibility*, which states that words can (or are likely to) occur with a given construction if (or to the degree that) their meanings are compatible.

Let us now turn to the methodological current. As its name suggests, quantitative corpus linguistics combines two approaches to language. First, it takes a linguistically-informed corpus-based interest in the whole range linguistic phenomena, as in traditional corpus linguistics (cf. e. g., Schlüter 2003 for phonology; Bybee and Scheibman 1999 for morphology; Fillmore and Atkins 1994 and Atkins and Levin 1995 for lexis; Renouf and Sinclair 1991 for grammar patterns; Rohdenburg 2003 for grammatical variation; Theakston et al. 2002 for language acquisition, etc.). Second, it combines this interest with a strict quantitative commitment, as found more typically in corpus-based computational linguistics (which is typically concerned with statistical language processing, cf. the overviews in Church and Mercer 1993; Jurafsky and Martin 2000; Manning and Schütze 1999; cf. below). This strict quantitative commitment has several methodological entailments that characterize work in quantitative corpus linguistics. First, the corpora used should be representative and balanced (unless there is a specific reason to use non-balanced corpora, for example, when studying register differences (cf. e. g., Biber 1988, 1993; cf. also the collostructional approaches in Wulff, Gries, and Stefanowitsch 2005, and Stefanowitsch and Gries, to appear). Second, instances of the linguistic phenomenon under investigation must be retrieved exhaustively, i. e., with maximal recall and precision. This typically requires careful manual or semi-manual post-editing; in this respect, quantitative corpus linguistics differs markedly from most corpus-based computational linguistics, where data are frequently processed automatically with an eye to maximizing recall and accepting non-maximal precision. Finally, the quantified data must be evaluated statistically. In this respect, quantitative corpus linguistics differs most markedly from most traditional corpus-linguistic work, which often (but by no means always) reports raw frequencies, but hardly ever subjects these frequencies to inferential statistical methods.

Despite the fact that the predominant corpus-linguistic traditions (at least in Europe) mostly do not share these commitments, there are, by now, a broad range of research traditions that do, and that we therefore regard as instances of quantitative corpus linguistics (cf. for example, Biber et al. 1999; Diessel and Tomasello 2005; Hay and Baayen 2002; Grondelaers et al. 2002; Jurafsky et al. 2001; Kilgarriff 1996; Krug 1998; Gries 2003b; Lapata et al. 2001; Leech 1992; Lüdeling and Evert 2003; Stefanowitsch 2004b; Markert and Nissim 2002; Martin, to appear; Brenier and Michaelis 2005; Roland and Jurafsky 2002; Sampson 2001; Wulff 2003, to list just a few).

2.2. Previous work on collostructional analysis

Collostructional analysis is the application of (quantitative) collocational analysis within a constructional view of language (hence its name, a blend of *construction* and *collocational analysis*).

Much of traditional work using collocational analysis proceeds as follows. The researcher retrieves (a sample of) all instances of the word under investigation (the *node word*) together with all words within some user-defined span (typically, between one and seven words to the left and right of the node word). The words occurring within this span (the *collocates* of the node word) are then weighted in terms of their importance, which is usually done on the basis of their frequency in the span. Finally, collocates exceeding a particular frequency threshold are inspected with respect to what they reveal about the node word.

This procedure is problematic in two respects. First, it ignores syntactic structure in the hope that relevant collocates (i. e., collocates with a linguistically significant relationship to the node word) will outnumber irrelevant ones. While this may work in some cases, it is obvious that a user-defined span does not do any justice to the complexities of linear linguistic structure. Recently, some researchers have begun to address this problem explicitly by relying on syntactic criteria rather than an arbitrary span for the retrieval of expressions (for example, Evert and Krenn [2001], who investigate adjective-noun collocations and support-verb structures in German; cf. Evert 2004: Chapter 1 for an overview and discussion).

Second, simply rank-ordering collocates in terms of their frequency ignores the complexity and the overall distribution of the data: since some words have a higher overall frequency than others, they have a higher general probability of occurrence so that their higher frequency among the collocates is not indicative of the node word's characteristics. More sophisticated approaches (e. g., Berry-Rogghe 1974; Church and Hanks 1990) therefore take into consideration the overall distribution of all words involved in a potential collocation to compute a measure of association strength capturing the relation between the node word(s) and its collocates.

Collostructional analysis is a natural extension of such quantitatively sophisticated collocational approaches within a construction-based framework: if grammatical structures are regarded as signs in the same way that words are, then their association to words (or other grammatical structures) can be investigated in the same way as associations between words. In doing so, collostructional analysis pays closer attention to grammatical structure than any previous approach.

The most straightforward implementation of this idea is collexeme analysis (Stefanowitsch and Gries 2003): instead of a node word, we look at a construction (such as the ditransitive, the past tense, the imperative, etc.), and instead of a user-defined span, we look at the words occurring in a particular slot provided by that construction (we refer to such words as [potential] *collexemes*). The latter are typically lemmatized, though looking at word forms is equally possible. In accordance with the methodological requirements of quantitative corpus linguistics, collexeme analysis is not based on the raw frequencies of collexemes, but on an evaluation of these frequencies in terms of some distributional statistic. The information needed for this evaluation is summarized schematically in Table 1.[2]

Table 1. *Collexeme analysis*

	Construction C	¬C (all other constructions)
Word L	*Freq (L+C)*	*Freq (L+¬C)*
¬L (all other words)	*Freq (¬L+C)*	*Freq (¬L+¬C)*

As an example, consider the distribution of the verb *give* inside and outside of the ditransitive construction, shown in Table 2 (numbers in italics are derived directly from the corpus, the others are the results of subtractions; for expository reasons we also show expected frequencies in parentheses).

A range of distributional statistics are available for the analysis of such frequency tables. For a variety of reasons, we have so far always

Table 2. *The distribution of* give *inside and outside the ditransitive in the ICE-GB (cf. Stefanowitsch and Gries 2003: 227−230)*

	give	Other verbs	Row totals
DITRANSITIVE	*461* (9)	574 (1,026)	*1,035*
Other constructions	699 (1151)	136,930 (136,478)	137,629
Column totals	*1,160*	137,504	*138,664*

used the Fisher-Yates Exact test.[3] More precisely, we have simply taken the p-value provided by this test as a measure of collostruction strength, i. e., a word's strength of attraction/repulsion to a construction. In this study, we use the same test where possible (but see Section 5 below); however, we use a log-transformed p-value as a measure of collostruction strength. This has several advantages. First, the p-value is not an intuitively very easy measure since the most interesting values are only located in the small range of 0.05 to 0 (and many linguists are unfamiliar with the scientific format employed for representing such small numbers). Second, the p-value as such can only represent the strength of the relation, but not its direction, i. e., whether an observed frequency is larger or smaller than the expected one. Third, the log-transformation allows the researcher to correlate collostruction strength with frequencies using linear correlation coefficients (cf. Gries, Hampe, and Schönefeld, submitted a). Specifically, we use the base-ten logarithm of the p-value as a measure of association strength (which we will refer to as p_{log10}) and change the sign of the resulting value to a plus when the observed frequency is higher than the expected one. This way, we get a value ranging from $-\infty$ (for strong repulsion) over 0 (no relation) to $+\infty$ (strong attraction); from this procedure it follows that log-transformed values with absolute values exceeding 1.30103 are significant at the level of 5 % (since $10^{-1.30103} = 0.05$), and values exceeding 2 and 3 are significant at the levels of 1 % and 0.1 % respectively.

When we apply this method to the data shown in Table 2, we get a p-value smaller than the smallest value that home-issue personal computers will output. For all practical purposes, thus, it corresponds to zero, which yields a collostruction strength value p_{log10} of infinity, indicating that *give* is associated with the ditransitive construction extremely strongly. In fact, it is the construction's most strongly attracted collexeme, which makes sense given the principle of semantic compatibility: the meanings of the ditransitive and the verb *give* both prominently include the component 'cause to receive' (cf. Stefanowitsch and Gries 2003).

Distinctive collexeme analysis follows the same basic logic but is concerned with collexemes that are significantly associated with a (particular slot in a) construction as compared to a semantically or functionally similar construction (for the collocation-based precursor of this method, cf. Church et al. 1991; Gries 2003a). The information required for a distinctive collexeme analysis is summarized schematically in Table 3.

Table 3. *Distinctive collexeme analysis*

	Construction C	¬Construction D
Word L	*Freq (L+C)*	*Freq (L+D)*
¬L (all other words)	*Freq (¬L+C)*	*Freq (¬L+D)*

As an example, consider the distribution of the verb *give* across the ditransitive construction and the prepositional dative shown in Table 4 (parentheses and italics are used as in Table 2 above).

Table 4. *The distribution of* give *in the ditransitive and the* to-*dative in the ICE*-GB *(from Gries and Stefanowitsch 2004a: 102)*

	give	Other verbs	Row totals
DITRANSITIVE	*461* (213)	574 (822)	*1,035*
TO-DATIVE	*146* (394)	1,773 (1,525)	*1,919*
Column totals	607	2,347	2,954

The Fisher-Yates Exact p-value for this distribution is 1.835954E-120, corresponding to a p_{log10}-value of 119.7361, indicating that *give* highly significantly prefers the ditransitive when compared to the prepositional dative. Again, this makes sense given the principle of semantic compatibility, since, as pointed out above, *give* and the ditransitive are essentially synonymous: both mean something like 'AGENT causes RECIPIENT to receive THEME'. In contrast, the prepositional dative has been argued to mean something like 'AGENT causes THEME to move to LOCATION'. Of course, this meaning is compatible with *give*, and thus *give* does occur in the prepositional dative; however, *give*'s meaning is *more compatible* with the ditransitive, and hence its association to the latter is stronger (cf. Gries and Stefanowitsch 2004a).

Both collexeme analysis and distinctive collexeme analysis have been applied to a variety of grammatical issues, for example, alternations (Gries and Stefanowitsch 2004a), constructional synonymy (Wulff, to appear), and grammaticalization (Hilpert, submitted). However, their applicability is not limited to grammatical phenomena. Its greater precision compared to collocational analysis (i. e., the fact that well-defined slots in a well-defined grammatical structure are used instead of an arbitrarily defined span) also makes it a valuable tool for lexical semantics (which we will not be concerned with here, but cf. the discussion of construction-dependent semantic prosody in Stefanowitsch and Gries 2003: 220−222).

3. Covarying-collexeme analysis

Often, a construction provides two (or more) slots which may be associated with sets of items whose semantic properties we want to investigate with respect to each other (a point we will return to at the end of the present section). The method presented in this paper, *covarying-collexeme analysis*, is a natural extension of our previous methods intended to deal with such situations.

Instead of looking at one slot in a construction and identifying the association strengths of lexical items occurring in this slot to the construction itself, we identify the association strength between pairs of lexical items occurring in two different slots of the same construction (in other words, we look at the way in which lexical items in one slot covary with those in another slot). This involves determining for each potential collexeme L occurring in slot 1, which potential collexemes in slot 2 co-occur with it significantly more often than expected. As above, this is done by comparing actual frequencies of co-occurrence with expected ones on the basis of a 2-by-2 distribution table. Such a table is shown schematically in Table 5.

Table 5. *Covarying collexeme analysis*

	M_{slot2} *(word M in slot 2)*	$\neg M_{slot2}$ *(all other words in slot 2)*
L_{slot1} *(word L in slot 1)*	*Freq* $(L_{slot1} + M_{slot2})$	*Freq* $(L_{slot1} + \neg M_{slot2})$
$\neg L_{slot1}$ *(all other words in slot 1)*	*Freq* $(\neg L_{slot1} + M_{slot2})$	*Freq* $(\neg L_{slot1} + \neg M_{slot2})$

As an example, consider the distribution of *fool* and *think* in the *into*-causative (as in *We must not* FOOL *ourselves into* THINKING *there is no longer any problem*), shown in Table 6 (again, parentheses indicate expected frequencies and italics indicate directly observed frequencies).

Applying the Fisher-Yates Exact test to this table yields a p-value of 8.708634e-31 corresponding to a p_{log10}-value of 30.06. This indicates that the association between *fool* and *think* in the *into*-causative is a relatively strong one (in fact, it is the most strongly associated covarying-collexeme pair in this construction).

Table 6. *The distribution of* fool *and* think *in the* into-*causative (BNC 1.0)*

	think	Other verbs	Row totals
fool	*46* (7)	31 (70)	*77*
Other verbs	101 (140)	1,408 (1369)	1,509
Column totals	*147*	1,439	*1,586*

Note that the way in which we have presented covarying-collexeme analysis here implicitly assumes a loosely constructional view; one grammatical construction (the *into*-causative) is taken as the critical context in which the co-occurrence of the two lexemes is investigated. Note also that from such a loosely constructional perspective, both collexeme analysis and distinctive-collexeme analysis appear to be essentially paradigmatic in nature: what is investigated is the *set of choices available in a given position* of a syntagmatic structure in relation to that structure itself. In contrast, covarying-collexeme analysis introduces a syntagmatic perspective in addition: what is investigated is the set of choices available in a given position of a syntagmatic structure *in relation to the set of choices available in another position* in the same structure. Thus, covarying collexemes are more like traditional collocates, except that their co-occurrence is not investigated in the corpus as a whole but only in that subset of the corpus made up by clauses fitting the construction type in question. However, the question of syntagmaticity and paradigmaticity is one of perspective: from a strictly constructional view, it is always the co-occurrence of linguistic signs that is investigated; in the case of collexeme analysis and distinctive collexeme analysis, this is the co-occurrence between two signs (lexeme and construction), in the case of covarying-collexeme analysis it is the co-occurrence between three signs ($lexeme_1$, $lexeme_2$, and construction). From this perspective, it is irrelevant that some signs are realized as elements in a certain sequence while other signs may be realized as the sequence itself, or as a mixture of elements and a certain sequence. From a theoretical point of view, adopting a strictly constructional or a loosely constructional view may have important repercussions, but from a methodological point of view, it is simply a matter of convenience; mathematically, nothing hinges on it. We could rewrite Table 6 by taking one of the lexical constructions as the critical context and then investigate the co-occurrence of the other lexical construction and the grammatical structure in question. This would not change the frequencies in the cross-table, and thus it would not affect the value of the association measure (but cf. Section 5 below).

Let us turn briefly to the issue of why we might want to investigate two slots in a given construction with respect to each other. At the most general level, the issue is whether and how different slots in a construction are related semantically. That they are expected to be related at all follows from the principle of semantic compatibility: since a word in any slot of a construction must be compatible with the semantics provided by the construction for that slot, there should be an overall coherence among all slots. We will refer to this expectation as the *Principle of Semantic Coherence* (note that this is not the *Semantic Coherence Principle* posited by Goldberg 1995: 50). Of course, this principle does not specify what *kind* of semantic coherence to expect for any given construction − this is an empirical question, to which we now turn.

4. Case studies

This section presents three case studies. The first and the third are based on the *British National Corpus* (Version 1.0), the second is based on the British component of the *International Corpus of English* and on the *Manchester Corpus* of language acquisition data. In each case study, we follow the principles of quantitative corpus linguistics and the procedures of collostructional analysis outlined above. We retrieve all instances of the construction in question. We use the annotation provided by the corpora to the degree that it is reliable, but since this reliability varies, we define all searches such that recall is 100 per cent and then achieve the same degree of precision by discarding all false hits by means of manual post-editing. The words in the slots under investigation are then lemmatized and subjected to the statistical procedure described in the preceding section using software routines written in R and Perl for this specific purpose (Gries 2004; Stefanowitsch 2004a).[4]

4.1. The into-*causative*

Let us begin with the *into*-causative already mentioned in the preceding section. The *into*-causative can be schematically presented as shown in (1a), and some examples are shown in (1b−d):

(1) a. $\mathrm{SUBJ}_{\mathrm{causer}}$ $\mathrm{V}_{\mathrm{causing.event}}$ $\mathrm{OBJ}_{\mathrm{causee}}$ [OBL *into* $\text{V-ing}_{\mathrm{resulting.event}}$]
b. … most customers are *misled into believing* that those guarantees and warranties cover far more than they do (BNC KRL)
c. … he was *forced into making* a reluctant announcement (BNC FR1)
d. Newley had been *tricked into revealing* his hiding place (BNC GUU)

The semantics of this construction is a little more specific than the subscripts suggest: previous work (Wierzbicka 1998) claims that is used in situations where the causee initially does not want to perform the resulting event but where the causer overcomes this resistance, typically by persuasion or trickery.

Given these semantic constraints, it is possible to predict roughly what verbs are likely to occur in the two slots. The causing-event slot should prefer verbs denoting actions that are suited to overcoming resistance, and the resulting-event slot should prefer verbs denoting actions that causees are likely not to want to perform. The first prediction is in fact borne out (cf. Stefanowitsch and Gries 2003; Gries and Stefanowitsch 2004b), the second prediction has not been tested yet (but cf. Section 5 below).

What is crucial in the present context, however, is that even this relatively precise description of the construction's semantics does not allow us to predict *combinations* of cause and result predicates. As mentioned in the preceding section, the principle of semantic compatibility predicts that these combinations should be semantically coherent, but it does not provide us with an expectation concerning the *kind* of semantic coherence.

Consider Table 7, which shows the 20 most strongly attracted and repelled combinations of cause and result verbs, calculated as described above (note that in the case of repelled combinations, only the first two are statistically significant).[5]

In general, the results show that in the case of the *into*-causative, the semantic coherence between the covarying collexemes is based on conventionalized causal frame sequences, i.e., on (culture-specific) frame-semantic knowledge of what typically causes what.

Take the first four pairs. All of them instantiate a relationship between a TRICKERY frame and a BELIEF frame. If we include all significant covarying-collexeme pairs with BELIEF results, it turns out that this relationship is in fact the predominant one for this frame in the *into*-causative (cf. Table 8).

The strong association between these two frames clearly reflects cultural knowledge about the way in which people influence each other's mental states.[6]

A second pair that reflects cultural knowledge concerning typical causal sequences of frames is *seduce into misbehaving*: *seduce* is significantly associated with five other verbs (*aspire, posit, yield, believe, invest*), two of which, like *misbehave*, are used in a romantic or sexual context, as shown in (2):

Table 7. *Attracted and repelled covarying collexemes in the* into-*causative (BNC 1.0)*

Attracted covarying-collexeme pairs in the *into*-causative		Repelled covarying-collexeme pairs in the *into*-causative	
fool into thinking	30.06	*force into thinking*	2.554
mislead into thinking	12.755	*coerce into thinking*	1.421
mislead into believing	8.355	*trick into making*	0.945
deceive into thinking	5.651	*push into thinking*	0.794
trick into parting	5.248	*trick into accepting*	0.717
encourage into farming	4.652	*bully into believing*	0.716
dragoon into serving	4.652	*talk into believing*	0.671
aggravate into producing	4.28	*trick into thinking*	0.634
panick into seizing	4.078	*lead into believing*	0.561
seduce into misbehaving	3.966	*talk into making*	0.536
delude into believing	3.952	*force into giving*	0.497
torture into revealing	3.75	*tempt into thinking*	0.42
force into hiding	3.676	*frighten into thinking*	0.363
shock into facing	3.546	*shame into thinking*	0.335
stimulate into developing	3.48	*provoke into giving*	0.295
blackmail into marrying	3.413	*lead into thinking*	0.28
drive into hiding	3.372	*provoke into accepting*	0.269
con into posting	3.35	*deceive into accepting*	0.269
intimidate into voting	3.335	*bully into giving*	0.266
move into gulping	3.2	*fool into accepting*	0.264

Table 8. *Significant covarying collexemes of* believe *and* think *in the* into-*causative (BNC 1.0)*

RESULT	CAUSE
believe	*mislead, delude, con, hoodwink, indoctrinate, dupe, fool, bluff, seduce, lull, bamboozle, brainwash*
think	*fool, mislead, deceive, delude, lull, brainwash*

(2) a. … A sexual go between, a secret agent planted to se*duce the enemy into misbehaving*, a chemical in massage oil which makes you tingle … (BNC KCU)

b. … that tenderness that came across so like loving. It mocked me, but at the same time ... I was being weakened by it, *seduced into yielding* to your power over me ... (BNC H9L)

c. … “I [love you], Ruth,” he breathed so passionately that she was almost seduced into believing him. But her reasoning cried out the truth … (BNC JY4)

The remaining verbs are used in contexts where somebody mistakenly acts in a certain way:

(3) a. The Smiths *seduce us into aspiring* to the same heroic pitch of failure and exile. (BNC AB3)
b. Bourdieu wonders how structural anthropologists could be *seduced into positing* the existence of the rule when informants were just using it as a strategy. (BNC GW4)
c. One investigator into the Maxwell scandal said: 'Maxwell was *seduced into investing* in Paris ...' (BNC AL2)

A third example of a conventionally associated pair of semantic frames is that manifested by *torture into revealing*. It is fair to say that getting someone to reveal something is the primary goal of torture. Again, the other significant covarying collexemes of *torture* confirm this association: they are *prove*, *admit*, and *confess.* Incidentally, the same association was found for a considerably larger data set, ten volumes of the British Newspaper *The Guardian*, in an earlier study (Gries and Stefanowitsch 2004b). Because of the larger data set, a number of significant associations emerged that did not manifest themselves in the present study, for example, the one between commercial transaction verbs and verbs of trickery and harassment shown in Table 9.

Table 9. *Collexemes of transaction verbs in the* into-*causative (The Guardian)*

RESULT	CAUSE
buy	*mislead*, *hoodwink*, *lure*, *entice*, *boss*, *pester*, *diddle*, *guilt-trip*, *scare*, *nag*, *pressure*, *steer*, *tempt*, *fool*
purchase	*mislead*, *lure*
pay	*con*, *dupe*, *harass*, *intimidate*, *scare*, *blackmail*, *tie*, *panick*, *mislead*, *shame*
overpay	*dupe*
sell	*panick*, *force*, *entrap*, *terrify*

All examples discussed here demonstrate not only the high degree of semantic coherence that holds between covarying collexemes, but also the high systematicity holding between *sets* of covarying collexemes. These associations are clearly not the exception, but the rule for the *into*-causative; many other examples can be found that plausibly reflect culture-specific frame-semantic knowledge (e. g., *dragoon* − *serve*, *blackmail* − *marry*, etc.).[7]

4.2. Possessive constructions

The *into*-causative has a relatively specific meaning, and thus, the fact that the analysis in the preceding section confirms the principle of semantic coherence is not altogether surprising. Let us therefore look at two much more abstract constructions, the *s*-genitive, shown in (4) and the *of*-construction show in (5), again with subscripts showing 'prototypical' semantic roles:

(4) a. $NP_{possessor}$'s $N_{possessee}$
 b. *John's book*
 c. *Mary's sister*

(5) a. det N_{whole} *of* NP_{part}
 b. *a cup of tea*
 c. *the edge of the area*

The semantics of these constructions is not as uncontroversial as the subscripts suggest. The basic meaning of the *s*-genitive has been analyzed as 'possession' (including ownership, kinship, and body-part relations) among others by Taylor (1996) and Stefanowitsch (2003; cf. also Gries and Stefanowitsch 2004a), and the basic meaning of the *of*-construction as 'partitive' by Langacker (1992) and Stefanowitsch (2003); however, other researchers have analyzed both constructions as meaningless syntactic formatives, which is not entirely implausible given the vast range of semantic relations that they encode.

The predictions for a covarying-collexeme analysis of the two constructions are straightforward: if the constructions have the basic meanings suggested in (4) and (5), we would expect semantic coherence effects based on these meanings; if they are empty formatives, we would expect either semantic coherence effects based on other kinds of semantic knowledge, or no coherence effects at all.

Let us begin with the *s*-genitive. Table 10 shows the 30 most significantly attracted head-modifier combinations in two corpora, the International Corpus of English, and, for reasons that will become clear presently, the caretaker language from the Manchester Corpus (a corpus of free conversations between children of age 2 to 5 and their caretakers). Note that proper names of persons and works of art were collapsed into single 'lemmas'.

The data from ICE-GB do not look promising for an approach that claims that the basic meaning of the *s*-genitive is 'possession', although the principle of semantic coherence holds. The supposedly basic meanings are hardly instantiated at all: there are two potential cases of ownership (*child's clothing*, which is more likely a genitival compound, and *Israel's zone*), two cases of kinship (*my friend* and *her mother*), and two case of body-part relations (*cow's teat* and perhaps *subject's voice*). The vast majority of cases thus encodes 'non-basic' meanings such as pro-

Table 10. *Attracted covarying collexemes in the* s-*genitive in two corpora*

Attracted NP_{head}-N_{mod} combinations in the *s*-genitive			
International Corpus of English (GB)		Caretakers in the Manchester Corpus	
[Pers. Name]'s [Work of Art]	33.904	*her hair*	84.209
widow's benefit	18.128	*my goodness*	70.181
your test	11.727	*[Pers. Name]'s toy*	57.542
girl's school	11.19	*her dress*	51.658
designer's studio	10.208	*my word*	48.665
your LEA	9.749	*[Pers. Name]'s igloo*	44.142
Jew's college	9.664	*Grandma's house*	42.348
earth's rotation	9.284	*her arm*	40.618
tomorrow's final	8.907	*her plant*	39.813
my friend	8.822	*doll's clothes*	35.212
child's clothing	8.084	*your sister*	29.635
her mother	8.076	*his head*	29.197
widow's pension	7.828	*his tail*	26.062
brewer's tie	7.69	*king's horse*	24.507
pride's purge	7.69	*your train*	23.988
boy's school	7.483	*my knee*	23.417
curate's egg	7.213	*my shop*	22.935
dog's mercury	7.213	*doll's hair*	22.068
Jaguar's dashboard	7.213	*your mouth*	20.886
BBC's correspondent	7.001	*your hand*	20.394
Israel's zone	6.912	*your finger*	19.791
[Pers. Name]'s resignation	6.796	*your boat*	19.53
Roland's synth	6.736	*my baby*	18.839
cow's teat	6.435	*your book*	18.586
farmer's workshop	6.435	*night's sleep*	18.078
firm's charge	6.435	*his Mummy*	17.753
subject's voice	6.394	*baby's bottle*	16.234
partner's earning	6.368	*his ear*	15.711
people's struggle	6.284	*panda's clothes*	15.229
moment's notice	6.243	*Mummy's knee*	14.935

ducer-product (*[Pers. Name]'s [Work of Art]*, *Roland's synth*), participant-event (*your test/LEA, earth's rotation*, *farmer's workshop*, *partner's earning*, *people's struggle*), time-event (*tomorrow's final*, *moment's notice*), group-member (*BBC's correspondent*), and, above all, a range of genitival compounds (i. e., the 'descriptive genitives' of traditional grammar, cf. Quirk et al. 1985: Section 5.122 for a discussion of the formal properties distinguishing these from 'true' genitives), which may be relatively literal (*widow's benefit/pension, girl's school*), or completely idiomatic (*pride's purge*, *curate's egg*, *dog's mercury*). The analysis of the *s*-genitive as a meaningless formative seems to be an attractive alternative.

This impression changes when we turn to the input-to-acquisition data (i. e., the caretaker language). Here, we find clear evidence of a semantic

Table 11. *Attracted covarying collexemes in the* of-*construction in two corpora*

Attracted NP_{head}-N_{mod} combinations in the of-construction			
International Corpus of English (GB)		Caretakers in the Manchester Corpus	
secretary of state	69.615	*cup of tea*	∞
sort of thing	55.51	*king of castle*	66.975
point of view	36.683	*one of those*	47.424
edge of area	33.466	*all of them*	47.178
instalment of hire	27.521	*first of all*	43.48
house of commons	25.822	*piece of paper*	38.73
point of order	25.199	*one of these*	33.37
edge of box	25.019	*drink of milk*	30.796
lot of love	24.395	*way of doing*	26.415
friend of mine	24.359	*bottom of garden*	26.264
gang of four	20.588	*picture of [Pers. Name]*	23.578
kind of thing	19.705	*tin of bean*	20.753
chairman of committee	19.687	*pair of trouser*	19.712
court of appeal	19.65	*tin of soup*	19.167
period of time	17.717	*tin of salmon*	18.482
member of staff	17.052	*two of them*	17.666
leader of party	16.437	*lot of noise*	16.89
rate of inflation	15.45	*way of getting*	16.453
inspector of tax	14.855	*lot of money*	16.184
interruption of employment	14.855	*ring of rose*	15.828
prisoner of war	14.824	*front of train*	15.545
quality of life	14.795	*bottle of milk*	15.057
university of London	14.526	*game of snap*	15.021
copy of letter	14.439	*top of there*	14.596
cup of tea	14.433	*bail of hay*	14.205
back of defence	14.298	*top of other*	14.147
bank of England	13.736	*lot of thing*	13.594
depth of [Number] metre	13.357	*bunch of grape*	13.546
group of people	13.35	*bar of soap*	13.536
department of health	13.215	*time of year*	12.883

prototype of possession. With the exception of two interjections (*my goodness*, *my word*) and one time-event relation *(good) night's sleep*, all of the top thirty collexeme pairs encode possession, body-part relations, or kinship.

In sum, both the balanced sample (the ICE-GB) and the input-to-acquisition data thus show semantic coherence. In the case of the balanced sample, this coherence is based on a wide variety of relations, all of which, however, plausibly figure prominently in our world knowledge of things that belong together. In the case of the input data, this is based on a semantic prototype – the collexeme pairs can plausibly be used by children to identify possession as the basic meaning of the *s*-genitive, although this basic meaning is subsequently diluted through an ever wider range of applications, ending in the kind of general head-modifier meaning evident in the ICE-GB data. Note that this argument is not affected by the fact that child-directed speech is focused on different kinds of 'things' than adult-directed speech (say, concrete objects, people, etc. as opposed to abstract concepts): first, child-directed speech *does* contain references to abstract concepts (activities, desires, etc.); second, what is at issue is that the *relations between things* that are encoded in the two registers differ markedly (for example, *producer-product* is a relationship between people and concrete objects, yet it is not among the most prominently encoded relations in child-directed speech).

A very similar difference emerges for the *of*-construction, whose top covarying-collexeme pairs in the two corpora are shown in Table 11.

The ICE-GB data do contain a number of instances of part-whole and quantity relations (*edge of area*, *edge of box*, *lot of love*, *period of time*, *member of staff*, *leader of party*, *cup of tea*, *back of defence*, *group of people*), but these are not so predominant as to force the conclusion that they constitute the basic meaning of the construction. Instead, we find again that there are many compound-like fixed expressions (*secretary of state*, *house of commons*, *gang of four*, *court of appeal*, *inspector of tax(es)*, *prisoner of war*, *University of London*, *Bank of England*, *Department of Health*), as well as a number of other semantic relations. Again, though, the situation is very different in the child-directed speech data, which show an overwhelming predominance of part-whole or quantity relations (the only exceptions being *king of castle*, *way of doing*, *picture of [Pers. Name]*, *way of getting*, *game of snap*, and *time of year*).[8]

In sum, there is again semantic coherence based on a clear semantic prototype in the input data which gradually resolves into a more general semantic coherence based on world knowledge.

4.3. The way-*construction*

Having looked at purely verbal collexeme pairs (in the *into*-causative) and purely nominal collexeme pairs (in the *s*-genitive and the *of*-construction), let us in conclusion turn to a collexeme pair that is mixed in terms of part of speech, a verb-preposition pair. The construction in question is the *way*-construction (Jackendoff 1990; Goldberg 1995: Chapter 9), shown in (6):

(6) a. $\text{SUBJ}_{\text{theme}}$ V_{move} POSS *way* [OBL P $\text{NP}]_{\text{path}}$
   b. He could find his way back to New York somehow (BNC A0U)
   c. [The dogs] had chewed their way through the wooden door of a garage (BNC AJD).

The semantics of this construction is again slightly more complex than suggested by the subscripts. According to Goldberg (1995: 199–209), there are two alternative readings: one of simple motion, as in (6b), and one of path creation, as in (6c). We will not be concerned with this difference here, but simply focus on the relationship between the (motion) verb and the (path) preposition in general. Again, we will be concerned with the question whether there are semantic coherence effects, and if so, of what kind they are. The specific expectation in this case is that the type of motion that is denoted by a given verbal collexeme is in some way compatible with the specific type of path denoted by the corresponding prepositional collexeme. Table 12 shows the thirty most strongly attracted and repelled collexeme pairs in the *way*-construction.[9]

A cursory inspection of the top collexeme-pairs clearly conveys a sense of coherence. For example, it makes sense that the verb *find* and the preposition *around* form a covarying collexeme pair, since both evoke a situation where the subject/theme does not follow a precisely laid-out path. Likewise, *thread* and *between* form a natural pair, since a threading motion requires at least two landmarks (for example two separate objects or two sides of an opening), and *between* refers to just such a configuration. Finally, both *worm* + *into* and *smash* + *into* complement each other, since entering a container often involves either finding and using a small opening (*worm*) or creating an opening (*smash*). The kind of coherence displayed by these cases is perhaps best described as an image-schematic (in the sense of Lakoff 1987) coherence, i. e., verbs and prepositions evoke certain abstract spatial relationships which must fit together.

In order to determine whether this type of coherence is a general property of verb-preposition pairs in the *way*-construction, let us look at selected classes of semantically similar prepositions and their significant verbal covarying collexemes. Consider the prepositions in Table 13, which all denote paths that are in some way convoluted and not determined by the goal that the subject/theme is moving towards, but by the nature of the environment they traverse in order to get there (all significant verbal collexemes are listed in decreasing order of association strength).

Clearly, the verbs associated with these prepositions contain semantic components that correspond to the characterization of the prepositions. Five classes in particular can be identified that meet this criterion: (i) verbs of careful movement (*feel*, *pick*, *inch*), (ii) verbs of forcibly creating a path (*pound*, *gobble*, *crunch*, *chivvy*, *gouge*, *slap*, *poke*, *steamroller*), (iii) verbs of navigation (*find*, *navigate*, *chart*, *negotiate*, *browse*, *trace*); perhaps related to these (iv) verbs of circumventing obstacles (*wind*, *wend*, *crab*, *curl*, *bump*), and (v) verbs of aimless motion (*sashay*, *wander*, *idle*,

Table 12. *Attracted and repelled covarying collexemes in the* way-*construction (BNC 1.0)*

Attracted verb-preposition combinations in the *way*-construction		Repelled verb-preposition combinations in the *way*-construction	
find one's way into	60.66	*make one's way through*	45.254
make one's way to	51.621	*make one's way into*	44.31
find one's way around	26.79	*find one's way through*	39.938
talk one's way out of	20.689	*work one's way to*	14.9
pay one's way Ø	17.866	*force one's way to*	13.068
push one's way through	17.687	*make one's way around*	12.569
force one's way into	17.377	*pick one's way to*	12.374
make one's way towards	15.864	*find one's way towards*	11.39
make one's way back to	15.553	*work one's way into*	9.575
find one's way about	14.818	*find one's way across*	8.125
pick one's way over	11.951	*make one's way in*	8.012
work one's way through	11.944	*find one's way up*	7.933
munch one's way through	11.525	*find one's way along*	7.672
thread one's way between	10.382	*make one's way out of*	6.46
work one's way up	10.198	*make one's way through to*	4.98
find one's way on to	10.172	*fight one's way into*	4.69
work one's way up from	10.1	*make one's way on to*	4.216
eat one's way through	9.9	*find one's way past*	4.041
fight one's way back into	9.413	*find one's way up to*	3.906
con one's way into	9.087	*find one's way down*	3.879
make one's way downstairs	8.907	*claw one's way through*	3.364
trick one's way into	8.533	*make one's way between*	3.175
worm one's way into	8.459	*make one's way back into*	3.078
work one's way up through	8.423	*work one's way back to*	2.853
cut one's way through	8.238	*make one's way about*	2.842
make one's way down	8.194	*feel one's way through*	2.782
pick one's way through	7.59	*wind one's way to*	2.655
smash one's way into	7.185	*weave one's way to*	2.655
pick one's way across	6.998	*find one's way out of*	2.615
spend one's way out of	6.933	*wind one's way into*	2.556

Table 13. *Collexemes of some* CONVOLUTED PATH *prepositions (BNC 1.0)*

PREPOSITION	VERB
around	*find, navigate, wind, pound, feel, chart, hoot, howl, scream, whine, whore, negotiate, browse, chuff, gobble*
across	*pick, wing, make, rattle, dance, inch, wend, crunch, belch, chivvy, crab, gouge, heave, hiss, hoover, knit, pulse, ripple, sashay, skitter, wander*
along	*feel, pick, inch, make, slap, poke, bump, continue, curl, glide, idle, row, skip, slither, spread, strangle, take, trace, whistle*
over	*pick, pray, sound, steamroller, trod, chuff, clatter, pull, lick, nibble, wing*

trod). Classes (i) and (ii) both refer to ways of dealing with a path determined by an uneven surface, classes (iii) and (iv) both refer to ways of dealing with (obstacles in) an unknown environment, and class (v) refers to motion events without any explicit goal at all.[10]

Next, consider the prepositions in Table 14, which all refer to paths that meet obstacles. Two clear classes of verbs can be identified that are image-schematically compatible: (i) verbs of circumvention (*weave*, *snake*, *leap*, *wind*, *thread*, *ease*), and verbs of navigation (*negotiate*, *steer*) and (ii) verbs of forcibly creating a path (*push*, *work*, *munch*, *eat*, *cut*, *chew*, *hack, chomp, shoulder, plough, carve, gnaw, punch, elbow, fight, bludgeon, saw, scythe, thrust*, *prod*, *wrestle*, *pole*).

Table 14. *Collexemes of some* OBSTACLE *prepositions (BNC 1.0)*

PREPOSITION	VERB
between	*pick, weave, snake, leap, paddle, wind*
through	*push, work, munch, eat, cut, pick, chew, thread, hack, chomp, shoulder, read, wind, weave, bluff, plough, carve, gnaw, smoke, punch, elbow, fight, bludgeon, negotiate, finger, flick, growl, pant, saw, scythe, search, slurp, tack*
past	*elbow, talk, thrust, ease, prod, wrestle, bluff, pole, steer*

Next, consider the prepositions in Table 15, which refer to paths leading from the outside to the inside of a container or vice versa. Similar to the OBSTACLE prepositions, the verbs associated with the first two of these, *in* and *out*, fall into two classes that are compatible with such a motion: (i) verbs of forcibly creating a path (*force*, *brave*, *knock*, *jab*, *dig*, *fight*, *shoot*, *box*), and (ii) verbs of moving through a small opening (*bow*, *weasel*, *wiggle*, *squeeze*). Thus, there is the same kind of image-schematic coherence found also with other prepositions. Matters are different with the prepositions *into* and *out of*, which are mostly associated with verbs of trickery and verbal force, resulting in a strong and probably non-arbitrary similarity to the *into*-causative discussed above. It seems, that these prepositions are not usually used with physical motion at all (though some of the verbs found with *in* and *out* also occur here). Why this should be the case is unclear at present, given that the prepositions seem semantically very similar to *in* and *out*. Presumably, a detailed analysis of the metaphorical concepts involved would yield insights into the coherence principles at work.

Finally, consider the preposition *up*, which specifies a path that must overcome gravity. Fittingly, this preposition is associated with the verbs *work*, *thug*, *haul*, *inch*, *sweat*, *forge*, *puff*, *bump*, *bobble*, *chug*, *clank*, *clutch*, *croak*, *groan*, *jolt*, *moan*, *toil*, *twist*, and *twitch*, most of which are associated with the expenditure of energy.

Table 15. *Collexemes of some* CONTAINER *prepositions (BNC 1.0)*

PREPOSITION	VERB
in	*force, buy, advertise, brave, knock, winkle, trick, bow, bundle, jab, weasel, wiggle*
out	*dig, swim, fight, buy, shoot, squeeze, box, back, joke, find, force*
into	*find, force, con, trick, worm, smash, kick, wangle, wheedle, buy, fire, muscle, sneak, fumble, break, earn, gamble, inveigle*
out	*of talk, spend, lie, fight, act, borrow, build, export, buy, bully, dig, think, tear, claw, wheedle, automate, chuckle, cost-cut, devalue, engineer, expand, grow, hit, invest, irritate, laugh, merge, rationalise, scrabble, stoop, type, punch, snake*

In sum, the twelve prepositions discussed here provide overwhelming evidence for the fact that verb-preposition pairs in the *way*-construction display image-schematic coherence. This is not entirely unexpected, since prepositions are essentially image-schematic in their semantics. The idea of image-schematic coherence receives further support by the construction's significantly repelled collexeme pairs shown in Table 12 above: they are overwhelmingly combinations of very general 'light verbs' that have very little image schematic content (*make*, *find*) with prepositions providing very rich image schematic content (*through*, *into*, *around*, *along*, *past*, etc.), or they are combinations of richly image-schematic verbs (*pick*, *fight*, *wind*) with the very abstract preposition *to*.

4.4. Interim summary: three types of semantic coherence

As predicted, covarying collexemes are heavily constrained by the semantic coherence principle. This is in line with the semantic compatibility principle discussed in our earlier work (Stefanowitsch and Gries 2003; Gries and Stefanowitsch 2004a, b), and thus it confirms one of the central tenets of (cognitive) construction grammar (but note that this principle is also found in other frameworks, e. g., LFG in the version presented by Pinker 1989).

More specifically, three types of semantic coherence were found: (i) coherence based in culture-specific frame-based knowledge (in the case of the *into*-causative and the balanced sample for the *s*-genitive and the *of*-construction); (ii), coherence based on semantic prototypes (in the case of the input-to-acquisition data for the *s*-genitive and the *of*-construction); and (iii), image-schematic coherence (in the case of the *way*-construction). Clearly, these do not exhaust the logical or empirical possibilities (consider, for example, the possibility of metaphorical coherence). Further research will undoubtedly lead to a more complete and fine-grained taxonomy.

5. System-based corrections to covarying-collexeme analysis

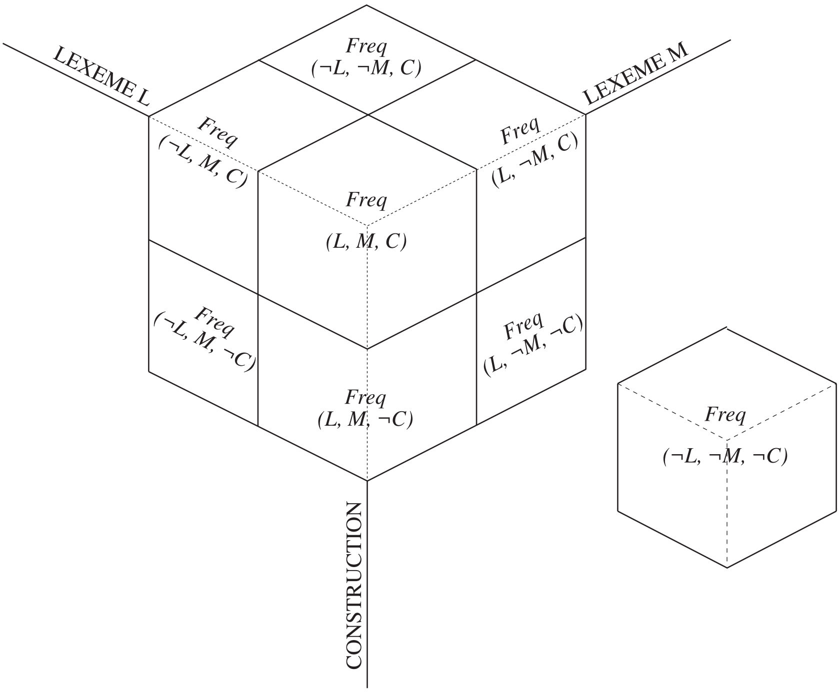
The methodology introduced in Section 3 and applied to a range of constructions in Section 4 has one potentially serious drawback: it restricts the investigation of the covariance of collexemes to one specific context (the construction in question), disregarding the frequencies of the construction and the collexemes in the remainder of the corpus). In other words, the version of covarying-collexeme analysis introduced above treats covarying-collexeme pairs as bigrams and investigates them in the subcorpus made up of the tokens of the construction in question; we will refer to this version as *item-based covarying-collexeme analysis*. This neglect of the overall corpus frequencies potentially distorts the results. A statistically stricter and more sophisticated version of the method should instead treat the covarying-collexeme pair together with the construction as a trigram and compare its observed frequency against its expected frequency in the complete corpus; we will refer to this version as system-based covarying-collexeme analysis (cf. also Hilpert 2004 for a similar attempt). Such a system-based method also allows us to address the question whether the association of a given collexeme_1-collexeme_2-construction trigram is stronger than any of the possible associations between just two of its elements in the absence of the third.

5.1. The basic correction

In order to calculate the association strength of the elements of a trigram consisting of two collexemes and a construction, we need to compare observed and expected frequencies in a 2*2*2 table, crossing the variables COLLEXEME 1 (Collexeme L vs. all other verbs in slot 1), COLLEXEME 2 (Collexeme M vs. all other verbs), and CONSTRUCTION (C vs. all other constructions). Such a table is shown schematically in Table 16.

To illustrate this procedure, let us return to the *into*-causative discussed in Section 4.1 above, and consider again *fool into thinking* as an example. Some of the frequencies necessary for the required calculation are available from the analysis discussed above: the frequency of *fool* in slot 1 of the *into*-causative (77), the frequency of *think* in slot 2 (147), the combination of the two (46), and the total number of *into*-causatives (1,586). In addition, we assume the total number of argument-structure constructions in the BNC to correspond to the total number of <s> tags (6,217,212). This is a vast oversimplification, of course, since (i) co-occurrence probabilities may be distorted due to different sentence lengths (cf. e. g., Holtsberg and Willners 2001) and (ii) sentences often contain more than one verb, and hence more than one argument struc-

Table 16. *System-based covarying-collexeme analysis*



ture construction, but this simplification is necessary for practical purposes: we need a clearly defined context within which to search for the single and joint occurrences of the verbs in question outside of the construction. This context would preferably be the clause, but clauses are not annotated in the BNC. The remaining frequencies needed for the analysis were then obtained as follows. First, we generated concordances of all sentences containing any form of all verbs occurring in slot 1 of the *into*-causative; for the example *fool into thinking*, this amounted to retrieving all occurrences of the strings *fool*, *fools*, *fooling* and *fooled* preceded and followed by word boundaries.[11] The BNC contains 2,752 such sentences. Second, we conducted an analogous search for the forms of the verb forms in slot 2, yielding 155,987 hits for *think/thinks/thinking/thought*. Third, we searched all concordances of the slot-1 verbs for all forms of the slot-2 verbs. On the basis of these three results and the frequencies already known, we were then able to calculate all frequencies required for the analysis summarized in Table 16, as shown in Table 17 for the example *fool into thinking*.

Table 17. $VERB_1$ * $VERB_2$ * CONSTRUCTION *for fool into thinking*

$VERB_1$	$VERB_2$	CONSTRUCTION	Computation	Frequency
fool	*think*	*into*-causative	46	46
fool	other	*into*-causative	77−46=	31
other	*think*	*into*-causative	147−46=	101
other	other	*into*-causative	1,586−(46+31+101)=	1,408
fool	*think*	other	259−46=	213
fool	other	other	2,752−(46+31+213)=	2,462
other	*think*	other	155,987−(46+101+213)=	155,627
other	other	other	6,217,212−all of the above=	6,057,324

The upper half of this table is familiar from section 4.1 above, where, on the basis of this information, we calculated the covarying-collexeme strength for *fool* and *think* within the *into*-causative in the item-based method (using the Fisher-Yates exact test). The figures in the lower half of the table correspond to the cell values for the added dimension in Table 16, i. e., the single and joint frequencies of the verbs outside of the construction. In sum, the combination of two covarying collexemes and the construction in which they occur is treated as a trigram (*fool* + *think* + *into*-causative), and in order to establish whether this trigram is significantly more or less frequent than expected any distributional statistic appropriate to 2*2*2 tables can be applied.

We decided to use a configural frequency analysis (CFA, cf. von Eye 1990; Krauth 1993) to identify the overall degree of attraction/repulsion of the three elements. CFA is a set of techniques to investigate multidimensional frequency tables, which, in addition to yielding a p-value for the table as a whole, also yield p-values for each individual cell by comparing the observed cell frequency with the expected one. Since our main interest is currently on only one of the cells, namely that where the two verbs and the into-causative co-occur, a CFA is ideally suited. The most common test used on CFA's is the chi-square test. However, since the conditions for applying the chi-square test are hardly ever met in the context of natural language data, it is not appropriate for our purposes (nor, for the same reasons, is the G2 value; cf. below) we use a variant of CFA based on the binomial test (Krauth 1993: Section 1.10). As in the case of the Fisher-Yates Exact p-values in Section 4 above, we $\log_{10}$-transform the binomial p-values, change the sign of the resulting value to indicate attraction and repulsion, and refrain from post-hoc correction. Table 18 shows the thirty most strongly attracted configuration types.

The first four attracted configuration types are identical to those obtained with the item-based method in Section 4.1 above. The ranks of

Table 18. *The thirty most strongly attracted* $VERB_1 + VERB_2$ + into-*causative trigrams*

Attracted trigrams (rank 1–15)	p_{log10}	Attracted trigrams (rank 16–30)	p_{log10}
fool into thinking	138.44	*seduce into believing*	14.22
mislead into thinking	77.11	*brainwash into thinking*	14.17
mislead into believing	62.71	*trick into thinking*	13.55
deceive into thinking	51.04	*trick into marrying*	12.82
fool into believing	34.2	*brainwash into believing*	12.36
delude into believing	29.26	*coerce into accepting*	12.24
con into believing	26.82	*force into accepting*	11.98
delude into thinking	24.61	*seduce into misbehaving*	11.82
trick into believing	24.16	*lull into thinking*	11.81
deceive into believing	20.98	*inveigle into taking*	11.62
dupe into believing	20.02	*blackmail into marrying*	11.41
hoodwink into believing	18.24	*socialise into accepting*	11.33
coerce into doing	17.53	*coerce into helping*	11.06
trick into parting	16	*lull into believing*	10.59
trick into signing	15.42	*trick into doing*	10.56

the following collexeme pairs (and some of the pairs themselves) differ from those in Section 4.1, but the regularities concerning the semantic patterning of the two slots still hold: we still find a strong predominance of verbs of trickery in slot 1, and these verbs still have the to be associated with mental predicates in slot 2. Conversely, there are a few examples where physical verbs in slot 1 (*coerce*, *force*) strongly co-occur with those that encode more physical results verbs (*do*, *accept*, *help*); this tendency is also strongly discernible among the next twenty configurations (*force into making/hiding*, *coerce into making/giving/behaving/acting* etc.). Finally, there is a strong overall preference for result predicates denoting mental processes: *think* and *believe* make up most of the slot 2 verbs in the most strongly attracted thirty combinations.[12]

The results for repelled collexemes, in contrast, differ markedly from those obtained in Section 4.1. Because of the way the expected frequencies are computed, many of them are between 0 and 1. Thus, repelled collexemes are extremely unlikely in 2*2*2 tables and are only observed for a few infrequent combinations of otherwise high-frequency verbs. The CFAs identified a total of just four repelled combinations, all of which were statistically non-significant, and which therefore do not allow a meaningful interpretation: *force into being*, *lead into having*, *make into going*, and *talk into having*.[13]

In sum, the system-based covarying-collexeme analysis does not result in a substantially different picture from that obtained via the item-based version although it is stricter with respect to the identification of repelled collexemes. This indicates that the item-based version – although computationally much less expensive, requiring minutes rather than days to calculate – may not generally be inferior in terms of the results it yields for qualitative interpretation.

However, the system-based covarying-collexeme analysis as such does not yet address the issue whether the elements of a given pair of covarying collexemes are also significantly associated outside of the construction in question, and more generally, whether the association of a given collexeme$_1$-collexeme$_2$-construction trigram (which we will refer to as *target trigram*) is stronger than any of the possible associations between just two of its elements in the absence of the third (to which we will refer below as *elsewhere contexts*, or *elsewhere trigrams*). This is a crucial issue both in a loosely and in a strictly constructional view, because there is always a possibility that two of the three elements are so strongly associated with each other that this association strength alone also accounts for the significant association of the whole trigram.

The strict and the loose constructionality approach differ in terms of which comparisons of target and elsewhere trigrams are of interest. Under a strict constructionality approach, grammatical constructions (like the *into*-causative) are no different in kind from lexical constructions (like the verbs occurring in the *into*-causative), and thus, none of the possible combinations of two elements and one other condition has an elevated status. In other words, we can meaningfully contrast the target trigram *fool* + *think* + *into*-causative with any of the three elsewhere trigrams *fool* + *think* + other, *fool* + other + *into*-causative, and other + *think* + *into*-causative. Under a loosely constructional view, in contrast, grammatical constructions are different in kind from lexical constructions: they are the frames which provide slots to be filled by lexical items. Thus, just one of the three comparisons just mentioned is relevant, namely the one contrasting the trigram *fool* + *think* + *into*-causative (the two words *in* the construction) with the trigram *fool* + *think* + other (the two words *outside* of the construction).

5.2. System-based corrections under a strictly or loosely constructional view

The next question is *how* to contrast the target trigram with a given elsewhere trigram. On the basis of the CFA introduced above, we suggest the following procedure.[14] First, we compute the p-value for each of the eight cells in each table (cf. Table 16), and $\log_{10}$-transform them as before. For each table, we then take the $p_{\log 10}$-value for the target-trigram cell (i. e., $\text{VERB}_1 + \text{VERB}_2 +$ *into*-causative) and individually subtract from it the $p_{\log 10}$-value for each relevant elsewhere trigram. The results of these subtractions provide a simple but elegant measure of association strength: the higher the value, the more strongly the elements are attracted to each other in the target trigram as compared to the elsewhere trigram; conversely, the smaller the value, the stronger the two elements are attracted in the elsewhere trigram. Thus, we get a measure of relative association strength, regardless of whether this association is significant in the target trigram, the elsewhere trigram, or both).[15]

Let us again clarify the procedure by means of the example *fool into thinking*. As we saw in Table 18 above, the trigram *fool* + *think* + *into*-causative yields a $\log_{10}$-transformed p-value of 138.44, which − since this is a positive value − indicates a very high degree of mutual attraction of the three elements. If we perform an analogous computation, for example, for the trigram *fool* + *think* + other, we obtain a $\log_{10}$-transformed p-value of 43.1; that is, *fool* and *think* are also strongly associated in the absence of the *into*-causative. Now, to determine whether and to what degree the association between the verbs in the construction differs from that in the elsewhere context, we simply subtract the latter value from the former. The result, 95.34 is still a very large, positive value, indicating that the association of *fool* and *think* in the *into*-causative strongly outweighs that of *fool* and *think* elsewhere. By analogy to the terminology employed in collocational studies (cf. Church et al. 1991; Gries 2003a) and our own earlier work, we call *fool into thinking* a covarying collexeme combination that is *distinctive* for the *into*-causative.

While this example involves contrasting the frequencies of the two verbs within and outside of the construction (a procedure of interest in a loosely constructional approach), we have already indicated that the same procedure can easily be performed for all remaining contrasts involving elsewhere trigrams containing just two of the three elements). In the remainder of this section, we will apply this procedure for the *into*-causative, discussing all three contrasts.

Let us begin with Table 19, which shows the trigrams whose attractions outweigh those of the elsewhere trigrams most strongly.

The first column of Table 19 contains those trigrams that are distinctive for the *into*-causative as compared to other constructions, i. e., those cases that are particularly interesting from a loosely-constructional perspective because the construction is most responsible for the overall attraction in the target trigram. Again, *fool into thinking* is the most distinctive covarying collexeme combination by far; moreover, many of the other highly attracted covarying collexemes from section 4.1 are still among the combinations most strongly attracted within the *into*-causative as opposed to the rest of the corpus. The predominance of combinations of mental cause and result predicates is even stronger than observed before, and we also find the familiar combinations of physical

Table 19. *Trigrams with a preference for* $\text{VERB}_1 + \text{VERB}_2$ + into-*causative*

$\text{VERB}_1 + \text{VERB}_2$ + CX vs. $\text{VERB}_1 + \text{VERB}_2$ + other		$\text{VERB}_1 + \text{VERB}_2$ + CX vs. VERB_1 + other + CX		$\text{VERB}_1 + \text{VERB}_2$ + CX vs. other + VERB_2 + CX	
fool – think	95.34	*fool – think*	99.13	*coax – be*	291.65
lead – do	87.17	*mislead – think*	32.07	*cohearse – be*	290.99
mislead – think	73.97	*make – defend*	22.85	*terrify – be*	290.23
force – get	59.23	*get – engineer*	21.67	*cajole – be*	288.79
mislead – believe	52.6	*get – play*	20.93	*goad – be*	288.73
deceive – think	48.28	*make – go*	20.2	*push – be*	288.49
force – do	31.81	*habitualise – misrecognise*	9.13	*nudge – be*	288.28
con – believe	25.92	*indoctrinate – believe*	8.64	*blackmail – be*	288.24
fool – believe	23.69	*move – gulp*	8.12	*conjure – be*	288.20
dupe – believe	18.93	*interest – buy*	7.22	*force – be*	288.00
trick – believe	18.85	*aggravate – produce*	6.62	*manoeuvre – be*	287.85
delude – believe	18.36	*drill – accept*	6.02	*compel – be*	287.73
coerce – do	17.17	*bluff – believe*	5.78	*stun – be*	287.67
deceive – believe	16.55	*school – think*	5.67	*shame – be*	287.59
trick – part	16.43	*softtalk – play*	5.43	*tempt – be*	287.59
trick – sign	15.09	*press – accept*	5.19	*stimulate – be*	287.46
lead – think	15.06	*condition – behave*	5.14	*fool – think*	122.96
force – think	14.77	*prick – bristle*	5.14	*trick – have*	106.68
hoodwink – believe	14.29	*softsoap – buy*	5.13	*pressurise – have*	105.82
trick – marry	13.49	*distract – vie*	5.05	*force – have*	103.11
draw – do	13.33	*coopt – circulate*	4.97	*goad – have*	102.63
brainwash – think	12.78	*tillerise – think*	4.89	*scare – have*	101.54
seduce – believe	12.78	*integrate – subsume*	4.89	*fool – have*	101.42
delude – think	12.08	*wow – pant*	4.78	*embarrass – have*	101.41
seduce – misbehave	11.82	*activate – endow*	4.69	*push – have*	100.73
brainwash – believe	11.37	*motivate – buy*	4.66	*pressure – have*	100.6
lull – believe	10.78	*castigate – reverse*	4.64	*talk – have*	99.45
coerce – help	10.69	*needle – confide*	4.5	*lead – have*	99.29
lull – think	10.64	*stampede – adopt*	4.48	*mislead – think*	52.65
coerce – accept	10.59	*hound – betray*	4.45	*coerce – do*	34.55

cause verbs (*lead*, *force*, *coerce*, *draw*) with physical result verbs (*get*, *do*, *help*). All in all, then, the results of this comparison are qualitatively very similar to the results obtained above, both by the item-based and by the system-based methodology. This makes sense given that in all cases we essentially take a loosely constructional view which takes the construction as a critical contexts within which the co-occurrence of verbs is investigated. Obviously, there are also a few differences. Most conspicuously, *force into thinking*, which was the most strongly repelled covarying collexeme combination according to the item-based method is now among the most strongly attracted ones, as are the formerly repelled *lead into doing*, *lead into thinking*. These results contradict the tendencies observed before, or rather, confirm that they are tendencies rather than categorical constraints.

The center column contains those cases where the target trigram is distinctive because of the verb in slot 2 as opposed to other verbs in the same slot, i. e., where the verb in slot 2 is most responsible for the overall degree of attraction in the target trigram. To illustrate this perspective, take the third-ranked pair *make* and *defend*. The $\log_{10}$-transformed p-value for *make* + *defend* + *into*-causative is 1.43, i. e., there is a relatively weak attraction among the three elements. However, the $\log_{10}$-transformed p-value of *make* + other + *into*-causative is -21.42, indicating that make and the *into*-causative do not co-occur together (are not attracted to each other) at all when *defend* is not in slot 2. Put differently, it is the occurrence of *defend* in slot 2 that is responsible for the overall result since it changes the repulsion of *make* + other + *into*-causative into an attraction of *make* + *defend* + *into*-causative (albeit a weak one). Turning to the results now, the first two cases are particularly interesting since *fool into thinking* and *mislead into thinking* are also among the topmost combinations in the first column. In other words, the first column shows that the high association strengths of *fool into thinking* and *mislead into thinking* are to a large degree due to the *into*-causative, and the center column shows that the second verb, *think*, plays a similarly prominent role for their high trigram values. Further down the list, we find cases where the trigram value is due to the positive influence of the verb in slot 2 alone (and in part to the negative value of the verb in slot 1, as in the *make* + *defend* + *into*-causative example above). Recall that we mentioned in Section 4.1 above that a general expectation is that the verbs in slot 2 should predominantly encode actions that the causee is unlikely to want to perform. A few obvious cases of such verbs can be found on the list (*misrecognise*, *accept*, *bristle*, *pant*, *betray*), but all in all, it is, of course, very much dependent on the context what someone wants or does not want to do, and hence the list as a whole is rather heterogeneous (but note again the prominence of mental processes in slot 2, which seems to be inherently related to the construction's semantics).

Finally, the third column contains those trigrams that are distinctive for the verb in slot 2 as opposed to other verbs in the same slot, i. e., cases where the verb in slot 1 contributes most substantially to the overall attraction of elements within the target trigram. To illustrate this situation, take, the first-ranked pair *coax*-*be*. While there is a moderate positive attraction of *coax* + *be* + *into*-causative ($p_{\log 10} = 3.02$), $p_{\log 10}$ for other + *be* + *into*-causative is highly negative ($p_{\log 10} = -288.62$), indicating that *be* is strongly dispreferred in the *into*-causative (as are most other stative verbs). In other words, the result of the subtraction (i. e., the tabulated value of 291.65) indicates that the association of *coax* to the *into*-causative is strong enough to revert the highly negative repulsion of other + *be* + *into*-causative into a moderate positive association, which makes sense given that *coax* is a paradigm case of a verb of trickery, which has been argued to be the central sense of the *into*-causative (cf. Stefanowitsch and Gries 2003: Section 3.2.1; Gries and Stefanowitsch 2004b). The inspection of the other items in the third column confirms this tendency. Most of the verbs in slot 2 are stative high frequency verbs, which – due to their tendency to occur frequently in all contexts – do not contribute much to the association strengths in the target trigams. In contrast, the verbs in slot 1 are all highly compatible with the *into*-causative and most of them are among the most strongly attracted verbs for this construction (cf. Stefanowitsch and Gries 2003). Their strong influence results in the high values of the $\log_{10}$-transformed differences and thus the strictly constructional perspective confirms tendencies observed in our earlier work.

Let us now turn to Table 20, which lists the target trigrams whose elements are less strongly attracted to each other than the corresponding elsewhere trigrams.

The first column contains the $VERB_1 + VERB_2$ pairs which are most strongly repelled in the *into*-causative as compared to all other constructions. To illustrate this situation, take *force* + *be* + other, which exhibits a very strong attraction as compared to *force* + *be* + *into*-causative, which is thus relatively dispreferred.[16] In line with our earlier observations, this effect is most reasonably attributed to the fact that this trigram combines a physical cause verb with a stative result verb. Going down the list, note how the sets of verbs in both slots are markedly different from those that were identified as distinctive for the construction. With respect to slot 1, physical verbs (*force*, *pressure*, *lead*, *draw*) and communication verbs (*talk*, *reason*) are much more frequent among the repelled trigrams, i. e., highly untypical of the *into*-causative. The same is true for the verbs in slot two: we find several broadly defined classes of verbs that are absent or very infrequent among the attracted trigrams in Table 19: motion verbs (*go*, *come*), communication verbs (*order*, *agree*), (change of) possession verbs (*give*, *have*), stative copula verbs (*be*, *become*) and action verbs (*fight*, *take*, *change*, *use*, *work*) etc.

Turning to the second column, i. e., those cases where strong difference must be attributed to $VERB_2$, we find that the top thirty repelled trigrams all contain the verb *trick*. Since this is among the most highly associated verbs in the *into*-causative, the verbs in slot 2 must be highly repelled in order to be able to change this association. Note that none of them are THINK or BELIEVE verbs (or mental verbs in general), confirming the strong association of TRICKERY and BELIEF in the *into*-causative. Admittedly, the items in the third column seem to contradict this trend, as many of them combine exactly these verb classes. It is unclear what to make of these results, given some important caveats concerning these results, to which we turn in conclusion of the present section.

Table 20. *Repelled* $VERB_1$ + $VERB_2$ + into-*causative trigrams*

$VERB_1$ + $VERB_2$ + CX vs. $VERB_1$ + $VERB_2$ + other		$VERB_1$ + $VERB_2$ + CX vs. $VERB_1$ + other + CX		$VERB_1$ + $VERB_2$ + CX vs. other + $VERB_2$ + CX	
force – be	−20.42	*trick – say*	−157.4	*blackmail – channel*	−140.74
force – have	−319.36	*trick – have*	−156.7	*lead – believe*	− 70.33
talk – do	−319.28	*trick – make*	−156.52	*kid – believe*	− 69.23
reason – give	−319.17	*trick – see*	−156.31	*frighten – believe*	− 69.05
lead – have	−319.05	*trick – like*	−156.02	*trap – believe*	− 69.01
talk – have	−287.8	*trick – work*	−155.88	*torture – believe*	− 68.57
force – fight	−204.84	*trick – back*	−155.55	*divert – believe*	− 68.50
talk – go	−202.84	*trick – leave*	−155.29	*cheat – believe*	− 68.47
lead – take	−197.29	*trick – feel*	−155.13	*bully – believe*	− 68.39
pressure – change	−166.29	*trick – become*	−155.1	*flatter – believe*	− 68.36
force – use	−145.13	*trick – try*	−154.96	*socialise – believe*	− 67.96
force – order	−130.52	*trick – provide*	−154.93	*mesmerise – believe*	− 67.76
lead – believe	−110.20	*trick – hold*	−154.9	*hypnotise – believe*	− 67.66
force – support	−105.58	*trick – open*	−154.88	*talk – believe*	− 67.61
talk – come	−104.77	*trick – meet*	−154.86	*beguile – believe*	− 67.54
tempt – be	−103.85	*trick – question*	−154.75	*confuse – believe*	− 65.38
talk – let	−102.5	*trick – pay*	−154.73	*manipulate – believe*	− 64.43
encourage – work	−102.36	*trick – talk*	−154.71	*bluff – believe*	− 63.41
force – work	− 96.32	*trick – stop*	−154.47	*indoctrinate – believe*	− 61.55
talk – agree	− 91.07	*trick – accept*	−154.32	*browbeat – believe*	− 61.39
force – become	− 89.16	*trick – drink*	−154.20	*bamboozle – believe*	− 61.28
force – resign	− 87.52	*trick – pick*	−154.14	*lull – believe*	− 58.52
talk – try	− 80.47	*trick – vote*	−154.07	*brainwash – believe*	− 56.75
pressure – have	− 74.75	*trick – dance*	−153.8	*seduce – believe*	− 53.83
persuade – take	− 73.29	*trick – kiss*	−153.64	*hoodwink – believe*	− 49.81
make – go	− 71.26	*trick – pretend*	−153.33	*dupe – believe*	− 46.96
encourage – take	− 68.48	*trick – bar*	−153.3	*deceive – believe*	− 44.94
force – make	− 65.05	*trick – disband*	−152.46	*trick – believe*	− 39.67
challenge – accept	− 64.1	*trick – come*	−151.72	*school – think*	− 37.41
draw – work	− 60.51	*trick – tell*	−150.68	*con – believe*	− 37.01

5.3. *Discussion*

The preceding section showed that many of the results of the simple, item-based version of covarying-collexeme analysis are confirmed, but it also yielded problematic data in some cases (specifically with respect to the repelled trigrams). It must be pointed out, however, that at present it is unclear to some degree what to make of either the problematic or the unproblematic data. The reason for this is inherent in the shortcut we had to make concerning the retrieval of the verbs under investigation in the elsewhere contexts: recall that it was impossible to rely on the POS-tagging in the BNC, and that therefore we used simple string searches instead. Unfortunately, this shortcut, which maximizes recall, comes with a considerable reduction in precision, in that it includes all zero-derived and gerundival nouns as well as all adjectives derived from past participles. This clearly distorts the results considerably by inflating the frequency of the items in question in the elsewhere context, thus (i) making it more difficult to identify attracted trigrams and (ii) making it easy to overestimate the degree of repulsion for repelled trigrams. This is particularly evident in the case of the second and third column in Table 20. In the second column, all repelled pairs contain some form of *trick*, including all nominal uses, and most of the verbs in slot 1 of the repelled pairs in the third column have zero-derived nouns or adjectives. Thus, the problematic data may be fully or partially accounted for by retrieval errors. From this perspective, the fact that the attracted trigrams confirm previous analysis becomes strong evidence for the latter: since the inflation of the frequencies of particular verbs outside of the target trigrams makes it more difficult for these verbs to achieve significant degrees of attraction within the target trigrams, we should pay special attention to those that manage anyway (*trick*, *fool*, etc.).

Given the current state of the art in corpus annotation (word class tagging and syntactic parsing), however, the potential for application of this method is severely limited, and the discussion in this section must remain largely programmatic. However, we believe that the results are promising enough to indicate that the method itself is a valuable addition to the inventory of collostructional (and collocational) analysis, even if it must await the arrival of more accurately annotated large corpora or better annotation tools to unfold its true potential. Of course, if and when such resources become available, this will raise a host of theoretical and methodological issues that we were (conveniently) able to ignore here. For example, using sentences rather than clauses as the defining unit for the elsewhere contexts is a simplification that should be avoided. Moreover, we presumably need to place additional restrictions on the elsewhere context. Most importantly, it would be highly desirable to hold dependency relations between the covarying collexemes constant, in order to prevent, for example, the combination *let's talk* to lower the significance of *talk into letting*). In this respect, system-based covarying-collexeme analysis is ahead of what is currently achievable if we take the methodological commitments of quantitative corpus linguistics seriously.

6. Conclusion

In this paper, we have presented a method for investigating the relationship between lexical items occurring in different slots of the same construction, and more generally, for investigating associations between triplets of linguistic signs. This method completes the family of collostructional methods that we began to introduce in earlier work (Stefanowitsch and Gries 2003; Gries and Stefanowitsch 2004a).

In our application of the method, we have dealt with two specific theoretical issues: first, semantic compatibility between constructions and lexical items and second, semantic coherence between lexical items occurring in different slots of the same construction. With respect to the first issue, the results presented here confirm a simple but important insight from previous collostructional studies: that there is such compatibility. This is by no means a trivial insight, since this result is only expected in theories of language that view grammatical constructions as meaningful, and hence it provides supports for such theories and against theories that view grammatical constructions as an epiphenomenon of the application of meaningless rules. With respect to the second issue, the paper has shown that lexical items occurring in different slots of a construction do indeed display semantic coherence. In itself, this would of course be a trivial insight if this coherence were purely topical; in this case, it could be fully accounted for by theories of textual coherence and would not have to be described at the level of syntactic constructions. However, instead of a purely textual coherence we found different kinds of coherence for different kinds of constructions, namely coherence based on world knowledge concerning associations between entities in the world, coherence based on frame-based knowledge about associations between events, coherence based on image-schematic properties, and coherence based on constructional semantic prototypes.

In addition, we have discussed different variants of the method. We drew a major distinction between the item-based variant, which looks at a potential pair of covarying collexemes only in the construction in question, and the system-based variant, which takes into consideration the overall single and joint frequencies of the words and the construction. With respect to the latter, we drew a second distinction between an application in a loosely-constructional view, where the co-occurrence of two lexical items within a construction is compared to their co-occurrence outside of this construction, and an application in a strictly-constructional view, where the co-occurrence of all three elements is contrasted with all co-occurrences of any two of the three elements. We found that, within a loosely-constructional view, the item-based variant is a reasonable shortcut; given the indeterminacy of many word forms with respect to their part of speech and the resulting tagging errors in all presently available corpora, the item-based method has a considerably higher precision and recall than the system-based one, and may thus be preferable in many situations despite its neglect of overall frequencies.

In this context, let us briefly comment on the issue of frequencies and collostruction strength. It is sometimes suggested that simple raw frequencies suffice to investigate associations between words (cf. e. g., Stubbs 1995) or between words and constructions (cf. Goldberg, Casenhiser, and Sethuraman 2004) or that the utility of inferential statistics in general is rather overestimated (cf. e. g., Kilgarriff, to appear). We disagree with these suggestions; although we acknowledge problems that may arise in the process of statistical evaluation, we believe that the advantages of judging observed frequencies in light of expected ones outweigh these problems. This does not mean that we discount frequency altogether. Frequency is *obviously* an important factor in language, and the point of our methods (and other quantitative corpus methods) is precisely to distinguish relevant frequency information from irrelevant information (cf. Gries, Hampe, and Schönefeld [to appear, submitted] for the high correlation between collostruction strength and frequency and experimental data confirming the predictive superiority of collostruction strength over frequency data in cases where the two measures make different predictions). From this perspective, the procedures described here and in our earlier work may simply be seen as ever more fine-grained corrections to a more naïve approach that would take simple frequencies at face value.

In conclusion, we stress emphatically that this paper can only be seen as the starting point for more in-depth studies of linguistic phenomena. Work that is currently underway includes research on the potential register or dialect specificity of collexemes (Stefanowitsch and Gries, to appear; Wulff, Gries, and Stefanowitsch 2005) and research on how to use statistical clustering techniques on covarying collexemes in order to identify semantic classes more objectively than we have so far done in the qualitative interpretation of our results (Gries and Stefanowitsch 2004c). However, the potential of the methods presented here (and of collostructional methods in general) is much wider, and hopefully future research will show the full extent (as well as the limits) of this potential.

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Notes

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1. Note that, in our view, any mechanism that captures the form/meaning relationship in question (e. g., lexical rules in LFG or HPSG) can be seen as logically

equivalent to a 'construction', and hence theories making use of such mechanisms can be argued to constitute constructional approaches. Thus, what counts for us is the notion of recurrent configurations of syntactic elements that are associated with recurrent semantic contents rather than the specific formalisms employed to represent such configurations.

2. This approach is similar in some respects to work by Evert and colleagues mentioned above, but it differs fundamentally in some key respects. First, and most importantly, collostructional analysis investigates constructions, i. e., grammatical form-meaning pairs of sometimes considerable complexity, rather than simple and relatively unspecific syntactic patterns such as adjective + noun. In other words, the retrieval of items is based on an identification of formal characteristics (e. g., phrase structure trees) *as well as* constructional meaning as determined by independent linguistic research rather than on the somewhat vaguer criterion on, say, "candidate pairs perceived as 'typical' combinations" (Evert and Krenn 2001: 2). In addition, the purpose of collostructional analysis as pursued so far is not just to identify (groups of) words, but also to shed light on the semantic regularities connected to particular syntactic patterns; for a similar approach cf. Schulte im Walde's (2003) work on subcategorization preferences of the kind listed in Levin (1993) or Brent (1993). Second, in collostructional analysis the constructions investigated are retrieved on the basis of fully manually corrected parse trees (as in our work based on the ICE-GB) or on the basis of a maximally underspecified search string followed by a manual correction even if this requires weeding out more than 10,000 false hits (as in Gries and Stefanowitsch 2004b). Although this is very labor-intensive, it is more precise than relying on a regular parser automatically pre-processing the data for automatic retrieval (cf. Evert 2004: section 2.3.3 for precision and recall results based on automatic preprocessing). Finally, the constructions retrieved for analysis are coded without exceptions, i. e., without disregarding low-frequency pairs (which is often done in other approaches for reasons of mere computational convenience).
3. There are many other measures that we could have used; cf. Daille (1994), Schone and Jurafsky (2001), or Weeber, Vos, and Baayen (2000) for discussion and evaluation. However, many of these statistics are problematic to some extent since (i) they involve distributional assumptions violated by natural language data and (ii) yield unreliable results when applied to low-frequency data. The Fisher-Yates Exact test we have been using is not subject to such theoretical and/or distributional shortcomings (for discussion of this test as a measure of collocational strength, cf. Pedersen 1996). We are aware of the fact that our procedure involves many different significance tests on a single data set and that usually corrections for multiple testing are employed in such contexts (cf. Wright 1992 for an overview of such corrections). However, since − as in our earlier work − we do not use the p-values for strict significance decisions but mostly for ranking, we do not usually apply post-hoc tests (but if needed, this could of course be done at little computational cost).
4. Anatol Stefanowitsch's *PerlClx 1.0* is written in Perl, Stefan Th. Gries's *CollAnalysis 3.0* is written in the R language. Both packages avoid on computational shortcuts for the summation of p-values and the resulting problems (cf. Evert 2004: 83) and are available under the GNU Public License from the authors upon request.
5. Arguably, *hiding* is more likely to be a noun here than a true present participle. It was erroneously coded as a verb and included in the analysis at an early point. Since the same data set was also used to perform the computationally extremely expensive calculations discussed below, we decided to accept this coding error rather than recalculate everything.

6. It also reflects a tendency, discussed in more detail in Gries and Stefanowitsch (2004b), for mental cause verbs to be associated with mental result verbs and for physical cause verbs to be associated with physical result verbs. Note that the two significantly repelled collexeme pairs are combinations of physical causes and mental results.
7. Note that we have simply claimed here that these associations are culture-specific, but current research (Wulff, Gries, and Stefanowitsch 2005) confirms these claims: a contrastive analysis of British and American English (journalese) shows, among other things, that many result frames that are associated with FORCE frames in British English are associated with VERBAL PERSUASION frames in American English.
8. *Way of doing* and *way of getting* should arguably be excluded because they contain present participles rather than true nouns; we followed the part-of-speech tagging of the Manchester Corpus here.
9. It is a matter of opinion whether this combination (as in *They paid their way*) can be regarded as an instance of the *way*-construction. Goldberg (1995: Chapter 9) argues that the oblique PP is an obligatory part of the construction, which would disqualify this case, and admittedly its behavior differs from the other cases, most obviously in that the subject and the possessive can refer to different entities (*She paid his way*, cf. **She made his way into the ballroom*). We decided to err on the side of precision here in order to maximize recall.
10. Note that here and elsewhere, as in earlier publications, we posit semantic classes post hoc and on the basis of what we consider plausibly to represent frame-based knowledge. In our view, this strategy is preferable to using predetermined semantic taxonomies (say, that of Levin [1993] or of the *FrameNet* project), since, first, it is unclear to us what predictions would follow from such predetermined classes for the issues under investigation, and second, such taxonomies simply do not have a sufficiently broad coverage in terms of the lexical items they include in order to be applied in the kind of exhaustive data retrieval strategy we employ here. However, we are, of course, well aware of the pitfalls of our strategy, and are currently exploring data-driven strategies for more objective classification (see Conclusions).
11. Initially, we had planned to utilize the POS-tagging of the BNC to that end. However, since the tagging error rate turned out to be enormously high especially for some low-frequency verbs, we decided to maximize recall and disregard the tags completely even though this inflates the numbers of hits for a few words including, say, *fool*, *talk*, and *force*, which also occur as nouns frequently. Including these nouns, however, only makes the test for attracted collexeme combinations stricter, as the higher overall frequencies of the words existing both as verbs and as nouns or adjectives leads to higher expected frequencies of co-occurrence in the *into*-causative, and thus significant results under these circumstances are even more indicative of some interesting relation between the lexical item and the construction.
12. A sceptic might argue that it does not make sense to compare covarying collexeme strengths calculated on the basis of the Fisher-Yates exact test to the present ones calculated on the basis of the exact binomial test. However, our concern is only with ranking collexemes rather than comparing exact p-values, and since the rankings resulting from both statistics are identical for all practical purposes ($\tau = 0.993$; $z = 51.1$; $p = 0$), this technical difference is irrelevant here.
13. It has been claimed that repulsion, i. e., a negative association between linguistic items is extremely infrequent (cf. Church et al. 1991: 124). For 2-by-2 tables, our

previous work on collostructions has shown that this claim is false, or at least too strong; however, for 2-by-2-by-2 tables, it does indeed seem to hold.

14. Let us briefly comment on three seemingly obvious alternatives to the procedure outlined below. First, and perhaps most obviously, one might use a procedure based on the comparison of the odds ratios of the appropriate 2-by-2 tables by means of the Mantel-Haenszel statistic. However, the Mantel Haenszel test tests a slightly different hypothesis, is very sensitive to low-frequency items, and can only be applied in the absence of three-way interactions (which we did in fact find in 44% of the all individual tables. A second obvious possibility is the use of multidimensional Chi-square tests or loglinear models (cf. Blaheta and Johnson 2001), but the low frequencies often encountered in natural language data unduly inflate Chi-square and G^2.
15. Cf. Wulff, Gries and Stefanowitsch (2005) and Stefanowitsch and Gries (to appear) for further examples and results of this approach.
16. P_{log10} for *force* + *be* + other was manually set to 320 since the computation of $p_{binomial}$ exceeds our available computing power, as mentioned above.

References

Atkins, Beryl T. Sue and Beth Levin
1995 Building on a corpus: A linguistic and lexicographical look at some near-synonyms. *International Journal of Lexicography* 8 (2), 85–114.

Berry-Rogghe, Godelieve L. M.
1974 Automatic identification of phrasal verbs. In Mitchell, J.L. (ed.), *Computers in the Humanities.* Edinburgh: Edinburgh University Press, 16–26.

Biber, Douglas
1988 *Variation across Speech and Writing*. Cambridge: Cambridge University Press.
1993 Using register-diversified corpora for general language studies. *Computational Linguistics* 19 (2), 219–241.

Biber, Douglas, Stig Johansson, Geoffrey Leech, Susan Conrad and Edward Finegan
1999 *Longman Grammar of Spoken and Written English*. Harlow, Essex: Pearson Education.

Blaheta, Don and Mark Johnson
2001 Unsupervised learning of multi-word verbs. *Proceedings of the ACL Workshop on Collocations*, 54–60.

Brenier, Jason M. and Laura A. Michaelis
2005 Optimization via syntactic amalgam: Syntax-prosody mismatch and copula doubling. *Corpus Linguistics and Linguistic Theory* 1 (1), 45–88.

Brent, Michael R.
1993 From grammar to lexicon: Unsupervised learning of lexical syntax. *Computational Linguistics* 19 (2), 243–262.

Bybee, Joan and Joanne Scheibman
1999 The effect of usage on degrees of constituency: The reduction of *don't* in English. *Linguistics* 37 (4), 575–596.

Church, Kenneth W. and Patrick Hanks
1990 Word association norms, mutual information, and lexicography. *Computational Linguistics* 16 (1), 22–29.

Church, Kenneth W., William Gale, Patrick Hanks and Donald Hindle
1991 Using statistics in lexical analysis. In Zernik, Uri (ed.), *Lexical Acquisition: Exploiting On-line Resources to Build a Lexicon*. Hillsdale, NJ: Lawrence Erlbaum, 115–164.

Church, Kenneth Ward and Robert L. Mercer
1993 Introduction the special issue on computational linguistics using large corpora. *Computational Linguistics* 19 (1), 1–24.
Croft, William
2001 *Radical Construction Grammar: Syntactic Theory in Typological Perspective*. Oxford: Oxford University Press.
Daille, Béatrice
1994 Approche mixte pour l'extraction automatique de terminologie: Statistiques lexicales et filtres linguistiques. Unpublished doctoral dissertation, University of Paris 7.
Diessel, Holger and Michael Tomasello
2005 Particle placement in early child language: A multifactorial analysis. *Corpus Linguistics and Linguistic Theory* 1 (1), 89–111.
Dunning, Ted
1993 Accurate methods for the statistics of surprise and coincidence. *Computational Linguistics* 19 (1), 61–74.
Evert, Stefan
2004 The Statistics of Word Cooccurrences: Word Pairs and Collocations. Unpublished doctoral dissertation, University of Stuttgart.
Evert, Stefan and Brigitte Krenn
2001 Methods for the qualitative evaluation of lexical association measures. *Proceedings of the 39th Annual Meeting of the Association for Computational Linguistics*, 188–195.
Eye, Alexander von
1990 *Introduction to Configural Frequency Analysis: The Search for Types and Antitypes in Cross-classifications*. Cambridge: Cambridge University Press.
Fillmore, Charles J.
1988 The mechanisms of 'Construction Grammar'. In Axmaker, Shelley, Annie Jaisser, and Helen Singmaster (eds.), *Proceedings of the Fourteenth Annual Meeting of the Berkeley Linguistics Society*. University of California, Berkeley: Berkeley Linguistics Society, 35–55.
Fillmore, Charles J. and Beryl T. Sue Atkins
1994 Starting where the dictionaries stop: The challenge of corpus lexicography. In Atkins, Beryl T. Sue and Antonio Zampolli (eds.), *Computational Approaches to the Lexicon*. Oxford: Oxford University Press, 349–393.
Fillmore, Charles J. and Paul Kay
1995 Construction Grammar. Unpublished manuscript, University of California at Berkeley.
Goldberg, Adele E.
1995 *Constructions. A Construction Grammar Approach to Argument Structure*. Chicago, IL: University of Chicago Press.
1999 The emergence of the semantics of argument structure constructions. In MacWhinney, Brian (ed.), *The Emergence of Language*. Mahwah, NJ: Lawrence Erlbaum, 197–212.
Goldberg, Adele E., Devin M. Casenhiser, and Nitya Sethuraman
2004 Learning argument structure generalizations. *Cognitive Linguistics* 15 (3), 289–316.
Gries, Stefan Th.
2003a Testing the sub-test: A collocational-overlap analysis of English *-ic* and *-ical* adjectives. *International Journal of Corpus Linguistics* 8 (1), 31–61.

2003b *Multifactorial Analysis in Corpus Linguistics: The Case of Particle Placement*: London/New York: Continuum Press.
2005 Coll.analysis 3.0. A program for R for Windows.

Gries, Stefan Th., Beate Hampe and Doris Schönefeld
to appear Converging evidence: Bringing together experimental data on the association between verbs and constructions. *Cognitive Linguistics.*
submitted Converging evidence II: More on the association of verbs and constructions.

Gries, Stefan Th. and Anatol Stefanowitsch
2004a Extending collostructional analysis: A corpus-based perspectives on 'alternations'. *International Journal of Corpus Linguistics* 9 (1), 97–129.
2004b Covarying collexemes in the *into*-causative. In Achard, Michel and Suzanne Kemmer (eds.), *Language, Culture, and Mind.* Stanford, CA: CSLI, 225–236.
submitted Cluster analysis and the identification of collexeme classes.

Gries, Stefan Th. and Stefanie Wulff
to appear Do foreign language learners also have constructions? Evidence from priming, sorting, and corpora. *Annual Review of Cognitive Linguistics.*

Grondelaers, Stefan, Dirk Speelman and Dirk Geeraerts
2002 Regressing on *er*. Statistical analysis of texts and language variation. In Morin, Anne and Pascal Sébillot (eds.), *6th International Conference on the Statistical Analysis of Textual Data*. Rennes: Institut National de Recherche en Informatique et en Automatique, 335–346.

Halliday, Michael A.K.
1985 *Introduction to Functional Grammar*. London: Edward Arnold.

Hay, Jennifer and R. Harald Baayen
2002 Parsing and productivity. In Booij, Geert E. and Jaap van Marle (eds.), *Yearbook of Morphology 2001*. Dordrecht: Kluwer, 203–235.

Hilpert, Martin
2004 Constructional polysemy in the English split infinitive. Paper presented at the Third International Conference on Construction Grammar, Marseille, France.
submitted Swedish future modals: A usage-base approach.

Holtsberg, Anders and Caroline Willners
2001 Statistics for sentential co-occurrence. *Lund University Working Papers in Linguistics* 48: 135–147.

Hopper, Paul
1987 Emergent grammar. In Aske, Jon, Natasha Beery, Laura Michaelis, and Hana Filip (eds.), *Thirteenth Annual Meeting of the Berkeley Linguistics Society*. University of California, Berkeley: Berkeley Linguistics Society, 139–157.

Jackendoff, Ray.
1990 *Semantic Structures*. Cambridge, MA: The M.I.T. Press.

Jurafsky, Daniel, Alan Bell, Michelle Gregory and William D. Raymond
2001 Probabilistic relations between words: Evidence from reduction in lexical production. In Bybee, Joan and Paul Hopper (eds.), *Frequency and the Emergence of Linguistic Structure*. Amsterdam/Philadelphia: John Benjamins, 229–254.

Jurafsky Daniel and James H. Martin.
2000 *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*. Upper Saddle River, NJ: Prentice-Hall.

Kilgarriff, Adam
1996 Putting frequencies in the dictionary. *International Journal of Lexicography* 10 (2), 135–155.
to appear Language is never, ever, ever, random. *Corpus Linguistics and Linguistic Theory* 1 (2).
Krauth, Joachim
1993 *Einführung in die Konfigurationsfrequenzanalyse (KFA)*. Weinheim: Beltz, Psychologie-Verlags-Union.
Krug, Manfred
1998 String frequency: A cognitive motivating factor in coalescence, language processing and linguistic change. *Journal of English Linguistics* 26 (4), 286–320.
Lakoff, George
1987 *Women, Fire, and Dangerous Things*. Chicago, IL: The University of Chicago Press.
Langacker, Ronald W.
1987 *Foundations of Cognitive Grammar,* vol. 1: *Theoretical Foundations*. Stanford, CA: Stanford University Press.
1992 The symbolic nature of cognitive grammar: The meaning of *of* and *of*-periphrasis. In Pütz, Martin (ed.), *Thirty Years of Linguistic Evolution. Papers in Honour of René Dirven*. Amsterdam/Philadelphia: Benjamins, 483–502.
Lapata, Maria, Frank Keller and Sabine Schulte im Walde
2001 Verb frame frequency as a predictor of verb bias. *Journal of Psycholinguistic Research* 30 (4), 419–435.
Leech, Geoffrey
1992 Corpora and theories of linguistic performance. In Svartvik, Jan (ed.), *Directions in Corpus Linguistics: Proceedings of Nobel symposium 82, Stockholm, 4–8 August 1991*. Berlin/New York: Mouton de Gruyter, 105–122.
Lüdeling, Anke and Stefan Evert
2003 Linguistic experience and productivity: Corpus evidence for fine-grained distinctions. In Archer, Dawn, Paul Rayson, Andrew Wilson, and Tony McEnery (eds.), *Proceedings of Corpus Linguistics 2003*, 475–483.
Manning, Christopher D. and Hinrich Schütze
2000 *Foundations of Statistical Natural Language Processing*. 2nd printing with corrections. Cambridge, MA: The M.I.T. Press.
Markert, Katja and Malvina Nissim
2002 Metonymy resolution as a classification task. In Yarowksy, David (ed.), *Proceedings of the 2002 Conference on Empirical Methods in Natural Language Processing*, 204–213.
Pedersen, Ted
1996 Fishing for exactness. *Proceedings of the South Central SAS(c) User Group 96*, 188–200.
Pinker, Stephen
1989 *Learnability and Cognition. The Acquisition of Argument Structure*. Cambridge, MA: The M.I.T. Press.
Quirk, Randolph, Sidney Greenbaum, Geoffrey Leech, and Jan Svartvik
1985 *A Comprehensive Grammar of the English Language*. Harlow: Longman.
Renouf, Antoinette and John McH. Sinclair
1991 Collocational frameworks in English. In Aijmer, Karin and Bengt Altenberg (eds.), *English Corpus Linguistics*. London: Longman, 128–143.

Roland, Douglas and Daniel Jurafsky
2002 Verb sense and subcategorization probabilities. In Merlo, Paola and Suzanne Stevenson (eds.), *The Lexical Basis of Sentence Processing: Formal, Computational and Experimental Issues*. Amsterdam/Philadelphia: John Benjamins, 303–324.

Sag, Ivan A., Thomas Wasow, and Emily Bender
2003 *Syntactic Theory: A Formal Introduction*. 2nd ed. Stanford, CA: CSLI Publications.

Sampson, Geoffrey
2001 *Empirical Linguistics*. London/New York: Continuum Press.

Schlüter, Julia
2003 Phonological determinants of grammatical variation in English: Chomsky's worst possible case. In Rohdenburg, Günter and Britta Mondorf (eds.), *Determinants of Grammatical Variation in English.* Berlin/New York: Mouton de Gruyter, 69–118.

Schone, Patrick and Daniel Jurafsky
2001 Is knowledge-free induction of multiword unit dictionary headwords a solved problem? In Lee, Lilian and Donna Harman (eds.), *Proceedings of the 2001 Conference on Empirical Methods in Natural Language Processing*, 100–108.

Schulte im Walde, Sabine
2003 Experiments on the Automatic Induction of German Semantic Verb Classes. Doctoral dissertation, University of Stuttgart.

Stefanowitsch, Anatol
2003 Constructional semantics as a limit to grammatical variation. In Rohdenburg, Günter and Britta Mondorf (eds.), *Determinants of Grammatical Variation in English*. Berlin/New York: Mouton de Gruyter, 155–173.
2004a PerlCLX 1.0. Perl package for collostructional analysis.
2004b Happiness in English and German: A metaphorical-pattern analysis. In Achard, Michel and Suzanne Kemmer (eds.), *Language*, *Culture*, *and Mind*. Stanford, CA: CSLI Publications, 137–149.
to appear a Quantitative Korpuslinguistik und sprachliche Wirklichkeit. In Solte-Gresser, Christiane, Karen Struve, and Natascha Ueckmann (eds.), *Von der Wirklichkeit zur Wissenschaft. Aktuelle Forschungsmethoden in den Sprach-, Literatur- undKulturwissenschaften*. Hamburg: LIT.
to appear b Corpus-based approaches to metaphor and metonymy. In Stefanowitsch, Anatol and Stefan Th. Gries (eds.), *Corpora in Cognitive Linguistics: Conceptual Mappings*. Amsterdam/Philadelphia: John Benjamins.

Stefanowitsch, Anatol and Stefan Th. Gries
2003 Collostructions: Investigating the interaction between words and constructions. *International Journal of Corpus Linguistics* 8 (2), 209–243.
to appear Register and constructional semantics: A collostructional case study. In Kristiansen, Gitte and René Dirven (eds.), *Cognitive Sociolinguistics: Language Variation, Cultural Models, Social Systems*. Berlin/New York: Mouton de Gruyter.

Stubbs, Michael
1995 Collocations and semantic profiles: On the cause of the trouble with quantitative studies. *Functions of Language* 2 (1), 23–55.

Taylor, John R.
1996 *Possessives in English. An Exploration in Cognitive Grammar*. Oxford: Clarendon Press.

Theakston, Anna L., Elena V.M. Lieven, Julian M. Pine and Caroline F. Rowland
2002 Going, going, gone: The acquisition of the verb 'go'. *Journal of Child Language* 29 (4), 783–811.

Weeber, Marc, Rein Vos, and R. Harald Baayen
2000 Extracting the lowest-frequency words: Pitfalls and possibilities. *Computational Linguistics* 26 (3), 301–17.

Wierzbicka, Anna
1998 The semantics of English causative constructions in a universal-typological perspective. In Tomasello, Michael (ed.), *The New Psychology of Language*. Hillsdale, NJ: Lawrence Erlbaum, 113–153.

Wright, S. Paul
1992 Adjusted p-values for simultaneous inference. *Biometrics* 48 (4), 1005–1013.

Wulff, Stefanie
2003 A multifactorial corpus analysis of adjective order in English. *International Journal of Corpus Linguistics* 8 (2), 245–282.

Wulff, Stefanie, Stefan Th. Gries and Anatol Stefanowitsch
2005 Brutal Brits and argumentative Americans: What collostructional analysis can tell us about lectal variation. Paper presented at the Ninth International Cognitive Linguistics Conference, Seoul, Korea, July 17–22, 2005.

Zelterman, Daniel, Ivan Siu-Fung Chan, and Paul W. Mielke
1995 Exact tests of significance in higher dimensional tables. *The American Statistician* 49 (4), 357–361.