PP Attachment and Argumenthood[*]

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1. Introduction

One of the best known kinds of syntactic ambiguity in the sentence processing literature involves the possible attachments of prepositional phrases (PPs) in V-NP-PP sequences, as exemplified by sentences like those in (1).

(1) a. The spy saw the cop with the telescope.
     b. The spy saw the cop with the revolver.

In sentence (1a), the PP *with the telescope* can be taken to modify the act of seeing, describing the instrument the spy used (a *VP-attached* reading), or to modify the cop, describing what he or she was holding (an *NP-attached* reading). In general, sentences of this form are usually not ambiguous once the whole sentence has been processed; for example, in the minimally contrasting sentence (1b) our knowledge of the real world dictates that revolvers cannot be used for seeing, and so the NP-attached reading is forced. But since prepositions like *with* can be used in various ways, an incremental parser cannot determine which attachment of a PP will be required until the disambiguating noun (e.g., *revolver*) has been encountered. To the extent that the human sentence processing mechanism attempts to assign a structure and an interpretation to incoming material word-by-word as soon as it is encountered (Marslen-Wilson 1973, 1975; Tyler & Marslen-Wilson 1977; Swinney 1979; Shillcock 1982; Garrod & Sanford 1985; Tanenhaus, Carlson & Seidenberg 1985; etc.), one can ask how it decides which structure to assign upon encountering a partial sentence like *The spy saw the cop with*: which attachment will it choose for the PP containing *with*. That is the question I explore in this paper.

Many answers to this question have already appeared in the literature. The best known has been developed by Lyn Frazier and her colleagues (Frazier 1978, 1987; Frazier & Fodor 1978; Frazier & Rayner 1982; etc.). Their claim is

that the human sentence processing mechanism preferentially attaches the PP to the VP rather than to the NP before encountering the object of the preposition, which results in processing difficulty if the content of the sentence actually requires NP attachment. Thus, (1b) should be harder to process than (1a). This preference is supposed to be an instance of a more general parsing principle, Minimal Attachment, given in (2), which is intended to account for a wide range of processing preferences.

(2)   Minimal Attachment: Attach incoming material into the phrase-marker being constructed using the fewest syntactic nodes consistent with the well-formedness rules of the language. (Frazier & Rayner 1982: 180)

The preference for VP-attachment over NP-attachment in sentences like (1) follows from (2) only under certain very specific assumptions about phrase structure (see Frazier 1990 for discussion). However, what is relevant here is simply the empirical claim that VP attachment is *always* tried first, and hence NP-attached PPs are *always* harder to process. Crucially, this account assumes that no information about the particular lexical items in the sentence is relevant to this initial parsing choice. That is, the initial parsing of such sequences is guided by a purely structural algorithm that looks only at the categorial status of the phrases involved, with no access to their argument structure or other syntactic properties.

Initial experimental support for Minimal Attachment came from a study by Rayner, Carlson, and Frazier (1983). On the assumption that revising a prior parsing decision requires more mental processing than confirming one, their theory predicts that experimental measures of processing load will show an increase when people encounter the word *revolver* in (1b), relative to the processing load when they encounter *telescope* in (1a). They conducted an eye-tracking study to measure fixation duration in the disambiguating region and confirmed the Minimal Attachment prediction using 12 pairs of sentences similar to (1).

Subsequently, Taraban and McClelland (1988) argued that while the verb-attachment preference obtained in the sentences that Rayner et al. tested, it is not a general preference. They set out to construct sentences that they believed would show the opposite preference, such as (3).

(3)   a.   The thieves stole all the paintings in the night.
      b.   The thieves stole all the paintings in the museum.

They tested their 18 new sentences along with Rayner et al.'s original 12 sentences in a self-paced reading experiment. This experiment replicated the verb-attachment preference for the original 12 sentences, but found a noun-attachment preference for the new sentences: that is, (3b) was easier to process than (3a). They concluded that PP-attachment preference is determined on the basis of expectations derived from all the information contained in the sentence up to the ambiguous preposition, combined with people's knowledge of the world, and that no *general* syntactic preference or strategy exists:

> The results we have reported cannot be accounted for by *any* syntactic principle of which we are aware—that is, by any principle that does not consider the content of the sentence—since our expectation effects occurred in sentences that differed in the content, and not in the syntactic constituents of the sentence frames. (p. 611)

While their finding does argue against Minimal Attachment as a general strategy, the explanation that Taraban and McClelland offer is unsatisfying, in that it implies that there are no generalizations to be made about this class of ambiguity. But they have not shown that; they have only ruled out one possible generalization. I argue that there is a different generalization, one proposed by Abney (1989).

Notice that neither of the above experiments controlled for the *type* of relationship between the PP and the N or V: whether it was an argument or a modifier.[1] Abney suggested that precisely this difference was at the heart of the parser's strategy: Prefer argument attachments over modifier attachments (cf. Gibson 1991; see Ford, Bresnan, and Kaplan 1982 for an early suggestion that argument structure could be relevant to PP attachment).[2] Abney gave the example in (4) to support this claim.

(4)   I thought about his interest in the Volvo.

It is intuitively clear that even though the sentence is ambiguous, people much prefer the interpretation where *in the Volvo* describes what he was interested in, not where I did my thinking. *In the Volvo* is an argument of the noun *interest*, but it is not an argument of the verb *thought (about)*. In contrast, in an example like (1) where the preference seems to be for verb attachment, I argue that the phrase *with a telescope* is an argument of *saw*; it is clearly not an argument of *the cop*. (Note that this strategy has the consequence that a particular sentence could facilitate either VP or NP attachment, depending on the lexical heads involved, since they determine the potential thematic relations of the attachments.) Thus, Abney's idea seems intuitively plausible. But is it compatible with the previous experimental findings? I argue that it is. I show in section 4 that the results of both experiments mentioned above could be explained by Abney's suggested preference, because many of the items involved a contrast between argument attachment to one site versus modifier attachment to the other. (See Sedivy and Spivey-Knowlton 1994 for similar qualitative observations.)

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[1] I deliberately avoid using the term *adjunct* in this paper because it has a structural sense in linguistic theory, under which it might not necessarily be synonymous with 'nonargument'; I use *modifier* as a cover term for nonarguments independent of their structural position. Note that Clifton et al. (1991) use the term *modifier* to cover both arguments and nonarguments; that is not the sense used here.

[2] I take the proposed preference for argument attachments to be a thematically-based feature of the parser. In contrast, Phillips (this volume) suggests that some of its effects should be derived from a structurally-driven preference, and that its application may thus depend crucially on the precise phrase structure positions of arguments of various lexical categories.

As a result, Clifton, Speer, and Abney (1991) sought to test Abney's idea directly. The sentence pairs that they tested were similar to those in the previous experiments, except that they tried to assess whether the relevant attachments were argument versus modifier attachments, using their own intuitions. With both a self-paced reading task and eye-tracking, they found that overall, NP-attachment sentences showed greater processing load (slower reading) in the PP, compared to VP-attachment sentences. They took this result to support the Minimal Attachment claim that the first preference of the parser is always to attach to the verb, regardless of argument structure. However, I suggest that, due to the particular sentences and methodology used in the experiment, this conclusion cannot actually be drawn based on these results. Several of their "modifier" examples actually involved VP-arguments and hence were not relevant to the hypothesis; other items were confounded by a variety of factors, to be discussed in section 4.3 below. Thus, I contend that neither this nor any other study to date has adequately assessed Abney's claim, and that an argument attachment preference explains the range of experimental findings better than the alternatives reviewed above. Another purpose of this paper is to suggest how this hypothesis can be tested directly, providing the underpinnings for experimental work that is currently underway.

Section 2 of this paper is devoted to a discussion of ways of making the distinction between arguments and modifiers, based on specific syntactic and semantic tests. In section 3 I begin applying these tests by examining the status of a large subset of the examples that have been used in previous experiments, namely those like (1a) that involve instrumental PPs headed by *with*. I show, contrary to previous claims in the literature, that they have a large number of argument properties. This point is central to establishing the plausibility of Abney's proposal vis-à-vis Rayner et al.'s experiment in particular. In section 4 I systematically assess all the sentences used in the three experiments mentioned above with regard to the argument versus modifier status of the possible attachments, to show that all three are consistent with an argument preference strategy. I also mention some methodological problems that might have contributed to the failure to find such a pattern. Conclusions are presented in section 5.

2.   Distinguishing arguments from modifiers

2.1   The distinction and the nature of the diagnostics

In order for the claim that argumenthood is the relevant factor in PP attachment to have real content rather than merely relabeling the phenomenon, there must be an independent definition of argumenthood that can be applied to the sentences under consideration. In section 2.2, I present a collection of diagnostics from various sources that I then apply to sentences from the experimental literature. (Many of these diagnostics are summarized in Cowper 1992, Radford 1988, and Pollard and Sag 1987.) It should be pointed out that most, if not all, of them have the status of heuristics; that is, no air-tight analysis tells us that they are guaranteed to be accurate in all circumstances, and they do not all draw the same dividing line between arguments and modifiers. Most likely, the diagnostics are sensitive to a couple of different structural properties of sentences

that are often but not always correlated. Hopefully, as linguistic theory progresses we will come to understand exactly which properties each is sensitive to and how these relate to one another, so that we might eventually be able to specify more precisely the distinction(s) that the parser relies upon. However, for the moment we must be satisfied that the diagnostics are sensitive to *some* syntactic properties of sentences, and to the extent that one or more such properties account for the parsing results, we can be confident that progress in our understanding is being made.

Let us begin by trying to get a handle on what the argument/modifier distinction is intended to capture. The following passage by Jackendoff is probably taken as the standard source on this matter; notice the crucial appeals to semantics.

> If we classify complements on semantic grounds, we find that there are three distinct ways in which a complement may be integrated into a semantic interpretation: as a functional argument, as a restrictive modifier, and as a nonrestrictive modifier . . . Let us begin with functional arguments. Those lexical items which strictly subcategorize phrases in their environment can be thought of as semantic functions which take as their arguments the interpretations of the strictly subcategorized phrases. For example, the verb *give* strictly subcategorizes a subject, an object, and an indirect object, and can be thought of as a semantic function $f(x, y, z)$ which maps ordered triples of terms into propositions . . . Similarly, the noun *part (of)* strictly subcategorizes an NP, and can be treated semantically as a function $g(x)$ which maps terms into terms. (Jackendoff 1977: 57)

Marantz (1984: 15) spells out what the semantic differences between arguments and modifiers are in principle:

> Certain roles are implicated in the semantics of verbs themselves, and arguments bearing these roles appear only with the verbs that select them . . . The verb dictates how to incorporate the constituents bearing its inherent semantic roles into the semantics of the clause of which it is the head. Noninherent semantic roles are adverbial in the sense that the semantic effect on the clause of the constituents bearing them is not determined by the head of the clause.

Subsequent authors have expressed the notion similarly:

> In general, a given adjunct can co-occur with a relatively broad range of heads while seeming to make a more-or-less uniform contribution to semantic content across that range. A given optional complement, by contrast, is typically limited in its distribution to co-occurrence with a small (and often semantically restricted) class of heads (possibly even a single item); in addition, the semantic contribution of the complement is idiosyncratically dependent upon the head. (Pollard & Sag 1987: 136)

See also Grimshaw 1990 (p. 108).

Thus, there seem to be two angles from which to view the semantic contrast: what the semantic function of a phrase is, as summarized in (5), and how the phrase itself receives its interpretation, as summarized in (6).

(5)   An argument fills a role in the relation described by its associated head, whose presence may be implied by the head. In contrast, a modifier predicates a separate property of its associated head or phrase.

(6)   A phrase P is an argument of a head H if the semantic contribution of P to the meaning of a sentence in which P is associated with H depends on the particular identity of H. Conversely, P is a modifier if its semantic contribution is relatively constant across a range of sentences in which it combines with different heads.

I take just one simple example with PPs to illustrate each contrast. In (7a), the head *student* implies the role of the thing being studied, in this case physics; the sentence tells us one property of John—that he studies physics. In (7b), *from Phoenix* predicates a separate property of the student; there is no head in the sentence that implies the presence of the role of geographical origin; the sentence as a whole describes two properties of John.

(7)   a.   John is a student of physics.
        b.   John is a student from Phoenix.

In the sentences in (8a), *on Sunday* can be interpreted correctly without any reference to the rest of the sentence and has the same meaning in each sentence (and in (8b), where the verb *is* carries no semantic information). In contrast, *on Sandy* in (8c–d) can only be interpreted with reference to the main verb; the meaning of this phrase is different across these sentences and different from what it would be with a semantically empty verb in a sentence like (8e).

(8)   a.   Kim camps/jogs/meditates on Sunday.
        b.   The meeting is on Sunday.
        c.   Kim depended/decided on Sandy.
        d.   The authorities blamed/pinned the arson on Sandy.
        e.   The spider is on Sandy.

It is of course possible (and, in my view, true) that argumenthood is not an all-or-nothing phenomenon, but that it comes in degrees. If it is fundamentally a semantic notion, that should not be surprising: it simply means (in light of (6)) that a preposition might make *some* contribution to the interpretation of a PP that it heads, while also relying on a semantic contribution from the main verb. If so, my version of Abney's claim is that the parser maximizes the *extent* of argument relations, that is, the degree of semantic cohesion among sentential elements; this means that an attachment that passes only two or three argument diagnostics is still expected to be preferred over one that passes none.

The reason we cannot simply leave the matter here is that while the semantic distinctions are crisp in the examples just mentioned, there are many cases where they are much hazier. In the next subsection I explore potentially more objective ways to get at these distinctions.

2.2 Some plausible diagnostics

In what follows I will discuss only diagnostics that have proved useful in assessing the type of sentence used in the experiments under discussion; I will thus limit myself to English and omit some tests relevant to argumenthood in general but not applicable to V-NP-PP ambiguities (in particular, tests for the argumenthood of clauses and of certain NPs; also, Grimshaw (1990) discusses tests for arguments of event nominals that are not helpful in the present context).[3] I first discuss diagnostics that are based in the semantic distinctions discussed above, progressing later to those that appear to be more purely syntactic.

2.2.1 Optionality

The most common rule of thumb for identifying arguments is that arguments to a particular lexical head can be obligatory, whereas modifiers are (almost) always optional,[4] but the converse is not true: there are optional arguments (Jackendoff 1977).[5] This test tells us that the PP in (9a) is functioning as an argument while the one in (10a) could be a modifier:[6]

(9)   a.   John put the book in the room.
          b.   *John put the book.

(10)   a.   John saw the book in the room.
        b.   John saw the book.

This test is not helpful with regard to arguments of nouns in the present context, however. For one thing, if the direct object noun in a V-NP-PP sentence took an obligatory PP argument, there would be no ambiguity of attachment of the PP—it would have to attach to the NP. Furthermore, as Grimshaw has shown, the class of nominals that take obligatory arguments is limited to those that describe complex events, and they generally require contextual support to force the

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[3] In fact, in Grimshaw's terms, the only kind of noun that can take arguments at all is a complex event nominal; other nouns can only have participants. In her terminology, what I refer to as arguments of nouns would be called *complements*, i.e., participants corresponding to an element of the lexical-conceptual structure of the head.

[4] Certain verbs appear to demand an adverbial modifier (Levin 1993):

(i)   a.   The teacher meant *(well).
       b.   That decision bodes *(well).

[5] The existence of optional arguments is controversial at the level of analysis. I take it as uncontroversial at the level of surface description, however, as exemplified in alternations like *John ate* versus *John ate the steak*.

[6] (10a) is of course ambiguous between NP or VP attachment of the PP; I am concentrating on the VP-attached reading here.

reading under which the argument is obligatory.[7] As it turns out, verbs that take obligatory PP arguments have also rarely been used in the experimental literature on this ambiguity (but see Ferreira & Clifton 1986 and Britt 1994), presumably because this would create an asymmetry between NP and VP attachment that could obscure other factors relevant to parsing; examples such as *I put the candy on the table in my mouth* (Gibson 1991) often seem to cause a conscious garden path, unlike cases where the verbal argument is optional.

2.2.2 Head-dependence

We can also try directly applying the generalization that arguments on the whole occur with a much narrower range of heads than modifiers do, as shown in (11) and (12).

(11) a. a man/woman/dog/muppet/scarecrow with gray hair
     b. a menu/napkin/glass/waitress/matchbook from Rosie's

     c. a member/*dog/*muppet/*scarecrow of Parliament
     d. a student/*punk/*watermelon/*Martian/*poodle/*VCR of physics

(12) a. John {died/sneezed/exploded/broke his arm/saw Fred/laughed at Bill} in the afternoon.
     b. John {informed/*saw/*hit/*admired/*surprised} his friend of the danger.

2.2.3 Iterativity

A third diagnostic that might be derivable from criterion (5) is what one might call the iterativity test: a role can be filled at most once,[8] whereas properties can be added on indefinitely, so modifier phrases can iterate while argument phrases cannot (cf. Fillmore's (1968) 'one case per simple sentence' principle, Bresnan's (1982) Biuniqueness condition, Pollard and Sag's (1987) Subcategorization Principle):

(13) a. *Chris rented the gazebo to yuppies, to libertarians.
     b. Kim met Sandy in Baltimore in the hotel lobby in a corner.

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[7] Thus, obligatorily transitive verbs have corresponding nominals that need not take an *of*-complement:

(i) a. *The doctor examined.
     b. The doctor's examination (of the patient) was successful.

But when a complex event reading is forced, obligatory transitivity resurfaces:

(ii) a. We express *(our feelings).
     b. The frequent expression *(of one's feelings) is desirable.

[8] This of course does not apply to conjunction: any role can be assigned to a conjoined NP, which means that the restrictions illustrated in (13)–(16) cannot derive solely from semantic considerations. Rather, one apparently must invoke a constraint on the mapping between argument structure and syntactic positions to say that a given role cannot be mapped to more than one position.

(14)   a.   *I met a student of biology, of molecular genetics.
         b.   I met a student with blue eyes with a wonderful smile.

(15)   a.   *They recognized the pictures of Kim, of Sandy.
         b.   They recognized the picture hanging in the lobby, hanging upside
               down.
         c.   They despised the picture in the house, in the basement.

(16)   a.   *She knew a member of Congress, of the House.
         b.   She knew a member in Northampton, in Massachusetts.

Care must taken in applying this test: if the iterated phrases are semantically in-compatible with each other then this can make the example seem bad for the wrong reason. For instance, the badness of *I met a student with blue eyes with green eyes* is uninformative. In general, good cases seem to require modifiers that refer to slightly different properties or else to a different level of detail or "grain size" (see Brunson 1992 for a more precise notion).

2.2.4   Copular paraphrases

A fourth diagnostic appears to derive straightforwardly from the seman-tic definitions of a modifier as a predicate. Since relative clauses are predicators of their head, if a constituent of NP can be paraphrased by a relative clause, it is a modifier; if it cannot, it is an argument.[9]

(17)   a.   a man (who was) from Paris
         b.   a man who had blue eyes (cf. a man with blue eyes)
         c.   the people (who were) on the payroll
         d.   the albums (that were) on the shelf

(18)   a.   the destruction (*that was) of the city
         b.   the weight (*that was) of the cow
         c.   a student (*who was) of physics
         d.   a member (*who was) of Parliament
         e.   the problem (*that was) with welfare

Notice that while most of these examples use the verb *be* in the relative clause in order to add as little semantics as possible, certain uses of *with* cannot be paraphrased by *be with* (e.g., *a man who was with blue eyes*), hence the use of *have* in (17b). A very similar test is proposed by Grimshaw (1990), who notes that modifiers can be separated from the head noun by a copula, but arguments (including complements, in her terms) cannot:

(19)   a.   John's dog.
         b.   The dog is John's.

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[9] Jackendoff (1977: 60) suggests this in passing as a diagnostic of modifiers; his particular example involved an alternation between *with* in the PP and *have* in the relative clause.

(20) a.   the book by/about/on Chomsky
      b.   The book was by/about/on Chomsky.

(21) a.   the destruction of the city
      b.   *The destruction was of the city.

(22) a.   the knowledge that Dukakis was ahead
      b.   *The knowledge was that Dukakis was ahead.

As far as I can see, these tests amount to the same thing. There is no precisely parallel test for arguments of verbs; the closest might be the VP pro-form tests, as described below, although for independent reasons these have additional quirks of their own.

2.2.5   Pro-form replacement

We turn now to diagnostics that seem to be based on syntactic properties, not just on semantics. They take advantage of the apparent fact that languages express arguments structurally closer to their heads than modifiers; it should be stressed again here that while it is very natural for structure to mirror interpretation in this way given a compositional semantics, there could well be exceptions to this generalization. Wherever possible, we should try to verify empirically that the syntactic generalizations do match up with independently motivated semantic criteria for argumenthood.

The first kind of diagnostic of this type is the pro-form replacement test. There seem to be words that can stand for a syntactic constituent encompassing a head and its internal arguments (at least) but that cannot stand for a head to the exclusion of any of these arguments. For instance, if a PP is obligatorily deleted when part of a noun phrase is replaced by *one*, that PP is an argument of the replaced head noun (23); if not, it is a modifier (24). (This contrast was first reported by Lakoff (1970a), who attributes the observation to Leroy Baker.)

(23) a.   *I like the King of Sweden, but I can't stand the one of Denmark.
      b.   *I climbed to the top of the hill, but not to the one of the
               mountain.
      c.   *I want the piece of pie, not the one of cake.
      d.   *They knew the answer to the quiz, not the one to the lab.[10]

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[10] Jackendoff attributes to Chomsky the claim that the *one*-test is valid only for PPs containing *of*. I take examples like those in (23d, e) to show that this is not true. In fact, I believe the test is general across prepositions. The only reason Jackendoff gives for doubting this is the following example, grammatical for him:

(i)   Arguments with Bill are less fruitful than ones with Harry.

This sentence ought to be bad, because there is other evidence to suggest that *argument with X* involves an argument PP. But (23f) indicates that the *one*-test does apply to *with* in general. To the extent that (i) does indeed involve an argument, I would an-

    e.   *The President proposed the solution to the foreign crisis, not the one to the domestic crisis.

    f.   *The President addressed the problem with welfare, not the one with Medicare.

(24) a.   She likes the car in the garage, not the one in the driveway.

       b.   I know the woman from Peel, not the one from London.

A couple of caveats are in order. First, this test is inapplicable if the intended antecedent noun is not countable/individuable. Thus, the badness of the examples in (25) does not bear on the argumenthood of the PPs, because *destruction* and *water* cannot be antecedents for a *one*-anaphor.

(25) a.   *The water in the lake is cleaner than the one in the river.

       b.   *the destruction of the city and the one of the village

A second complication, noted by Jackendoff (1977), is that there is also a numeral *one* that does not obey the same principles as anaphoric *one*; the former occurs in (26a). One should not be misled into thinking that (26a) shows that *of water* is not an argument. The numeral *one*, unlike the anaphoric *one*, cannot be pluralized, so (26b) unambiguously contains the latter, and since it is bad, *of water* is an argument by this test. (26c) shows a good case of plural anaphoric *one*.

(26) a.   Bill has two quarts of wine and one of water.

       b.   *the quarts of wine and the ones of water

       c.   the cars on the lot and the ones in the showroom

There are a couple of corresponding tests for verbal constituents. The most frequently cited is the *do so* test, originally discussed by Lakoff and Ross (1976 [1966]). If a constituent is obligatorily deleted when part of a verb phrase is replaced by *do so*, that phrase is an argument; if not, it is a modifier.

(27) a.   *Sue cooked lunch, and Fred did so dinner.

       b.   *John described the film to Mary, and Fred did so to Sue.

       c.   *John put a book on the table, and Sue did so on the shelf.

(28) a.   Sue asked Fred to cook dinner, and he did so.

       b.   John filled out the form in pen, and Mary did so in pencil.

       c.   John put a book on the table in the morning, and Sue did so in the afternoon.

Parallel to the restriction on N heads being replaced by *one*, the constraint here is that the verb replaced by *do so* cannot be stative, hence the badness of **Bill knew the answer, and Harry did so, too.*

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alyze it as an exception of the same kind as *the picture of Bill and the one of Sally*, to be discussed at the end of this subsection.

Another construction that also involves *do* and almost always yields the same results as *do so* replacement is pseudo-clefting. (Vestergaard (1977) attributes the original use of this construction for diagnosing constituency to Klima (1962).)

(29) a.   What John did on Tuesday was meet Mary.
       b.   *What John did on the shelf was put the book.

(30) a.   What Chris did in the backyard was cook dinner.
       b.   *What Fred did to Mary was describe the film.

The advantage to this test might be that it is less sensitive to focus effects. Since the phrase we are concerned with will usually be sentence-final in the *do so* test, it could be subject to effects of focus, because final position often carries focus (Rochemont & Culicover 1990), but it will not be final in the pseudo-cleft test, and in fact will generally not be focused at all, since pseudo-clefting itself focuses the post-copular material. (See Brunson 1992 for discussion.) This probably accounts for certain cases where a *do so* clause sounds better than terrible, while the counterpart pseudo-cleft is still completely out.

(31) a.   ??Lou handed a book to the parents, and Mary did so to the kids.
       b.   *What Lou did to the kids was hand a book.

(32) a.   ?If you want to talk about it, don't do so to Fred.
       b.   *What John did to Fred was talk about it.   (Vestergaard 1977)

As we will see in section 4.1, there might be an additional difference between the two constructions as well. Thus, it is recommended that both be tested.

A third such construction, according to Pesetsky (1995), is verb-projection fronting, which I generally avoid as a test because of its awkwardness.

(33) a.   John said he would give the book to them, and give the book to them he did on Tuesday.

       b.   *John said he would give the book, and give the book he did to them on Tuesday.

The standard analysis of both nominal and verbal pro-forms laid out by Jackendoff (1977) has been that they are lexically specified as single-bar-level projections (N-bar or V-bar), and that all the internal arguments of a head are projected within those projections, whereas modifiers generally must be projected higher. The technical details of this could be problematic under some current theories of phrase structure (e.g., because of binary branching, the idea that intermediate bar-level projections cannot be referred to or do not even exist, etc.), so that it might be more appealing today to analyze the constraints on pro-forms as semantic rather than syntactic. The idea would be that pro-forms can replace only

semantically complete units,[11] where semantic completion implies the inclusion of at least all internal arguments. I will take up this idea again in section 3; with one proviso noted there, I assume the validity of these tests, regardless of their eventual explanation.

Note that a semantic account of verbal pro-forms might predict that nonarguments that happen to be able to appear within V-bar, e.g., manner adverbs (see section 2.2.6), should not be obligatorily replaced by the pro-form, whereas a pure syntax account seems to force this. Thus, the fact that (34) is not a contradiction seems to favour the semantic approach.

(34)   Mary walked quickly to the park, and John did so slowly.

However, there are potential ways out for the syntactic approach, for instance by claiming that *quickly* has moved by a stylistic rule and is not inside V-bar at the level of the grammar at which the antecedent of *did so* is established. Thus, there might be little empirical basis for choosing between the syntactic and semantic analyses.

2.2.6   Ordering

A second pair of tests relying on essentially the same assumptions about phrase structure are the ordering tests: arguments generally must precede modifiers (again, see Jackendoff 1977).[12] Thus, given one element known to be a modifier, if it can occur following but not preceding the crucial element, the latter is an argument (35)–(37). If order between them is free, the crucial element is a modifier (38).

(35)   a.   a member of Parliament with gray hair
         b.   *a member with gray hair of Parliament

(36)   a.   While we were flying home, I gave the ring to my girlfriend over Buffalo.
         b.   *While we were flying home, I gave the ring over Buffalo to my girlfriend.

(37)   a.   John saw the mouse three times on Sunday.
         b.   *John offered the gift three times to Mary.

(38)   a.   a man from Paris with gray hair
         b.   a man with gray hair from Paris

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[11] This idea follows a suggestion by Alec Marantz (personal communication).

[12] One class of exceptions to this involves clausal arguments, which generally *can* be preceded by modifiers, e.g., *Sandy proved to her class **yesterday** that the world is round*. I do not take a stand on what allows this possibility (a preference for putting heavier items later is an obvious candidate), but I assume with most researchers that the behaviour of non-clausal arguments represents the normal case.

Again, this is not entirely true. One class of exceptions noted by Jackendoff (1977) is that manner adverbs can precede PP arguments in VP, e.g., *John gave the beans quickly to Bill*. He suggests that this is a derived order, probably involving rightward movement of the PP (although he also entertains leftward adverb movement). Pollard and Sag (1987) point out that constituents in VP can often be reordered so that they superficially violate the ordering generalization, but they point out that such reordering is usually correlated with focus on the clause-final constituent. For example, (39) focuses the indirect object, which concomitantly requires a certain amount of stress.

(39)   Lou handed a book last Sunday to the kids.

Hence, if in a given sentence it is impossible to put focal stress on some *nonfinal* constituent, the word order is not a base order. The following examples make this clearer (small caps are used to indicate emphasis).

(40)   a.   *Lou handed a book last SUNDAY to the kids.
        b.   *Chris put a book after LUNCH on the table.

(41)   a.   Chris read a book last SUNDAY after lunch.
        b.   Chris read a book after LUNCH last Sunday.

(42)   a.   They complained to the LANDLORD about the tenants.
        b.   They complained about the TENANTS to the landlord.

(43)   a.   She argued with her BROTHER about the inheritance.
        b.   She argued about the INHERITANCE with her brother.

(44)   a.   He climbed into the HOUSE through the window.
        b.   He climbed through the WINDOW into the house.

Thus, (40a and b) confirm that *to the kids* and *on the table* are arguments. Conversely, the PPs in (41)–(44) are grammatical in either order without focus. Thus the PPs in each sentence pair must be of the same type—modifiers in (41), arguments in (42)–(44) by other tests. According to Pollard and Sag's suggestion, the manner adverb fact noted above does not reflect rightward movement of the PP, since emphasis on the adverb is fine: *John gave the beans QUICKLY to Bill*. Thus, the PP is not obligatorily focused, as it would be if it had undergone rightward shift. Therefore, manner adverbs should simply be avoided in using the ordering test, and the stress test should be applied before other sentences are accepted as evidence.

2.2.7   *Extraction*

Finally, I come to the most problematic tests, both descriptively and theoretically, namely A-bar extraction tests.[13] It has been widely noted that ex-

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[13] I do not attempt to deal with potential diagnostic information that we might deduce from restrictions on A-movement. It is conceivable that the possibility of

traction of arguments and extraction from arguments are freer than extraction of modifiers (standardly called adjuncts in this context) and extraction from modifiers. However, the exact division between possible and impossible extractions has been hard to draw. Nonetheless, I suggest that certain kinds of extraction can profitably be used to diagnose argumenthood.

Let us begin with some canonical examples of argument versus modifier PPs in NPs. *Wh*-extraction out of an NP in object position, moving the NP complement of the P and stranding the P, seems to be good for arguments and bad for modifiers (Radford 1988):

(45) a. What branch of physics are you a student of?
      b. *What color hair are you a student with?

Additional examples are given in (46) and (47), where judgements pertain to the NP-attached reading of the PP.[14] The large number of examples is intended to indicate that this is a very general contrast, not a quirk of the particular choice of preposition or other lexical items. For reasons of space, I do not illustrate subsequent points for every example, but the reader can verify their generality.

(46) a. Which cake did you eat a piece of?
      b. Which problem did the President suggest a solution to?
      c. Which cow did you measure the weight of?
      d. What do you generally receive requests for?
      e. Which table did you wax the top of?
      f. What did John drink a glass of?
      g. Who do you have a strong belief in?
      h. Which program did the government deny a problem with?
      i. Which person did you see a picture of?

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preposition stranding under passivization correlates with argumenthood, as suggested by contrasts like *John was talked about* versus **Thursday hasn't been eaten since*. However, this test is generally not useful for V-NP-PP structures because only the direct object can be passivized (except in idioms). Furthermore, there are clearly many other factors at work and their nature is poorly understood (see Hornstein & Weinberg 1981).

[14] Jackendoff (1977) noted essentially this contrast, although his examples avoided overt preposition stranding:

(i)   a. Fathers of which children had fun?
      b. I met some children the fathers of whom like to drink.
(ii) a. *Fathers with which children had fun?
      b. *I met some children the fathers with whom like to drink.

Since his constructions strike me as more awkward than simple questions and do not seem to sharpen the contrast, I do not discuss them further here. However, they could be appealed to in cases where one is concerned that the preposition involved might not allow overt stranding at all. It has been noted (e.g., by van Riemsdijk (1978)) that certain prepositions disallow stranding in all environments, for example, *during*. This is not an issue for any of the contrasts above: it is easy to construct environments where *with, in, from, on,* and *around* can be stranded.

(47) a.   *Which house did you like a picture in?
      b.   *What kind of icing did you like a cake with?
      c.   *Which shelf did you dislike a book on?
      d.   *What kind of revolver did the spy know a cop with?
      e.   *Which take-out restaurant did she eat a burger from?
      f.   *Which intersection did she recommend a bookstore near?
      g.   *Which fireplace did you admire a vase over?
      h.   *Which finger did the woman own a ring around?

Unfortunately, there are numerous ways in which this test can give misleading results if one is not careful.[15] Most importantly, this extraction is gradiently sensitive to the pre-head material in the NP containing the PP that is extracted from, as noted by Chomsky (1973), such that the following become progressively worse:

(48) a.   Which problem did the President suggest solutions to?
      b. (?)Which problem did the President suggest a solution to?
      c.   ?Which problem did the President suggest the solution to?
      d. ??Which problem did the President suggest that solution to?
      e. ?*Which problem did the President suggest her solution to?
      f.   *Which problem did the President suggest Hillary's solution to?

The relevant factor here is generally assumed to be specificity (hence Chomsky's Specified Subject Condition and Fiengo and Higginbotham's (1981) Specificity Condition); the consequence is that the extraction test could yield a false negative unless the relevant NP is nonspecific, which is why most of the examples above involved indefinite determiners.[16] Notice that extraction from a modifier PP does not show gradations like (48): it is consistently bad regardless of the pre-head material in NP.

(49) a.   *What kind of revolver did the spy know a cop with?
      b.   *What kind of revolver did the spy know the cop with?
      c.   *What kind of revolver did the spy know that cop with?
      d.   *What kind of revolver did the spy know Hillary's cop with?

The extraction test can also mislead us in the opposite direction, yielding grammatical results for the wrong reasons. For example, Bach and Horn

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[15] In addition to constraints discussed here, there are some restrictions on *wh*-movement out of PPs that are not relevant as long as we restrict ourselves to V-NP-PP examples—see Kuno 1973.

[16] Note that (46c, e) include definite determiners and yet are still grammatical. The reason appears to be that mass and generic nouns are nonspecific even with a definite determiner (Fiengo & Higginbotham 1981; Culicover & Wilkins 1984). Thus, the following is OK: *Which city did you witness the destruction of?* In fact, this example would sound extremely odd without *the*. Thus, for purposes of applying the extraction test it is fine to use a definite determiner if it makes the example sound good, but if it sounds bad, one should worry that specificity might be the culprit, and try to construct a nonspecific example.

(1976) note that the following sentences do not unambiguously involve extraction from NP:

(50) a. Who did you write a book about?
      b. Who did you take a picture of?

The reason is that *write* also licenses a PP headed by *about*, independent of *book*, as in *John wrote about Nixon*. We know that this PP is also licensed by transitive uses of *write*, because of the goodness of *John wrote it about Nixon*—since pronouns disallow attachment of a PP to them, the PP in this example must be outside the direct object. Although intransitive *take* does not allow an *of*-phrase, we can have *John took it of Mary* (e.g., in response to *Where did that picture come from?*). Thus, (50) tells us nothing at all about the possibility of extracting from NPs of the form *book about X*. The solution is to apply the test using a main verb that is shown independently to disallow the relevant NP-external PPs, for instance, *see* or *find*: it turns out in these cases that extraction is still possible, so these seem to be argument PPs.[17]

(51) a. *I found it about Nixon.
      b. Who did you find a book about (when you were browsing at the
          bookstore)?

(52) a. *I saw it of Mary.
      b. Who did you see a picture of?

Once these two confounds are factored out, there might still be a problem for the proposed test. Culicover and Wilkins claim that the following exam-

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[17] Bach and Horn, who wish to argue that there are *no* true cases of extraction out of NP, claim that when the verb itself cannot license the PP from which extraction is attempted, the extraction becomes impossible, regardless of the internal structure of NP containing the PP. (See Chomsky 1977 and Koster 1978 for counterproposals.) They cite the following examples as bad (note that (ia, b) would then explicitly contradict (51b) and (52b)):

(i)   a. *Who did they destroy pictures of?
      b. *Who did you see a book about?
      c. *Who did John burn a large green book about?
      d. *What did you request an article about?
      e. *Who did you believe stories about?
      f. *What did you discuss the growth of?

While many of these admittedly sound a bit awkward, for me they are all still clearly better than the starred examples in (47). In some cases, the oddness seems to carry over from the declarative counterpart, for instance, *?I believed stories about the Loch Ness monster* (cf. (ie)). In others, the source of the oddness is more obscure. Culicover and Wilkins (1984) agree with the general assessment that many of Bach and Horn's starred examples are not very bad. They also show that whatever residual badness there is generally cannot be attributed to the NP containing the PP itself, since when the main verb is replaced the examples become fine. Thus, I conclude that there really is extraction from PPs in NPs, at least when the PP is an argument.

ple is clearly ambiguous, allowing an NP-attached reading for the PP as well as a VP-attached reading:

(53)   Which city did Jack buy a house in?

The NP-attached reading of the *in*-phrase would clearly be a modifier according to all our other tests, so this is a potential case of extraction out of a modifier being good. However, I for one find the relevant reading quite unstable. When there is a perfect VP reading around, it is very difficult to see the NP reading as bad, even in cases where we know (by changing the main verb) that it is. I have encountered a couple of other apparent counterexamples that do not seem to be attributable to a VP reading.

(54)   a.   (?)Which city did you meet a man from?
        b.   (?)Which factory do you fear a strike in?
        c.   (?)Which books did you like the lettering on?[18]

Here the PPs are clearly modifiers on the NP reading, yet the sentences seem more or less OK. I would like to claim, however, that such cases do not reflect actual grammaticality of extraction from modifiers, but are due (in some admittedly obscure way) to extragrammatical factors. (See below for a similar claim from the literature about VP-modifier extractions.). There is one piece of suggestive evidence in this regard. The extractions in (54), but not those in (46), seem substantially worse to me if the object NP is made more complex:

(55)   a.   ??Which city did you meet a rich elderly man from?
        b.   ??Which factory do you fear a long and dangerous strike in?
        c.   ??Which books did you like the tiny embossed lettering on?

(56)   a.   Which subject did you meet a rich elderly student of?
        b.   Which cake did you eat a huge mouthwatering piece of?
        c.   Which problem did the President suggest a dangerous new solution to?
        d.   Which tenets of democracy do you have a strong and heartfelt belief in?
        e.   Which MITWPL volumes did we receive an urgent foreign request for?

        Let me make one more point about extraction from NPs. Since preposition stranding is known to be a somewhat quirky process in English (and is highly marked crosslinguistically), one might think that the apparent correlation between extraction and argumenthood is spurious and that the true factor determining acceptability is, say, whether phrasal stress licenses cliticization of the preposition. There is evidence, however, that this contrast has nothing to do with stranding per se. Exactly the same distinction arises if the entire PP is pied

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[18] Inspired by an example in Ross 1967.

piped under *wh*-movement, once one factors out the across-the-board stiltedness of pied piping in general:

(57) a. Of what branch of physics are you a student?
       b. To which problem did the President suggest a solution?
       c. For which books do you generally receive requests?

(58) a. *With what color hair are you a student?
       b. *In which house did you like a picture?
       c. *On which shelf did you dislike a book?

Thus, it seems reasonable to assume that one could use the pied-piping version of the test with prepositions that disfavour stranding.[19]

It appears that two conclusions can be drawn given our current understanding of this phenomenon. First, there is a clear one-way implication: if extraction is bad, the PP is not an argument (assuming a suitable range of verbs has been tried). Second, if an apparently good extraction degrades in more complex structures then it is probably a modifier extraction, and if it does not it is probably an argument extraction.

Let us turn now to extraction of/from PPs that are arguments versus modifiers of V(P). Here the descriptive facts are somewhat better known. There are numerous apparent cases illustrated in (59)[20] where a preposition-stranding extraction from a verbal modifier PP is as good as extractions from arguments (60).[21]

(59) a. Which park did you meet a friend in?
       b. What day did John leave on?
       c. a concert which Bill slept at
       d. a mandolin concert that you don't have to wear a hearing aid to
       e. the person that John put the books on the shelves with
       f. How many hours did they argue for?

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[19] In fact, pied piping might sharpen some contrasts: at least some of the examples in (54) seem more clearly bad under pied piping. I have no explanation for this difference.

[20] Some examples from Pesetsky 1995.

[21] There are also bad modifier extractions, but these may all involve prepositions that never allow stranding, such as (i). Pesetsky (1995) notes that many marginal examples seem to sound better as relative clauses than as matrix questions, as shown in (ii):

(i)   *What did they leave notwithstanding?

(ii) a. ?a concert which Bill slept during
       b. ?*Which break should we leave during?

He also suggests that semantic complexity might correlate with the resistance of certain prepositions to stranding.

(60)   a.   Which table did Harry put the mouse on?
         b.   Which friend did you give a book to?
         c.   What information did they ask the committee for?

As was the case with NP PPs, pied piping seems to mirror stranding, in this case not showing an argument/modifier asymmetry either:

(61)   a.   In which park did you meet a friend?
         b.   On what day did John leave?
         c.   a mandolin concert to which you don't have to wear a hearing aid

(62)   a.   On which table did Harry put the mouse?
         b.   To which friend did you give a book?

However, the facts in (59) might be misleading. Hornstein and Weinberg (1981) note that some apparent extractions from modifier PPs become much worse when the structure is complicated; this leads them to suggest that such extractions are ungrammatical but can sometimes be judged acceptable due to processing strategies that seem to ignore certain constraints of the grammar (e.g., bounding):

(63)   a.   ??What day didn't John take the car on?
         b.   *It was Sunday that John left for Europe from La Guardia on.
         c.   *The third act of *Othello* is tough to leave the theater after.
         d.   ??It was Central Park that Bill agreed to meet Susan on his way
                 home in.

(Notice that pied piping makes most of (63) just about perfect.) As with NP attachments, such degradation does not seem to occur with the argument cases:

(64)   a.   Which of the many tables was it tough for Harry to decide to
                 finally put the mouse on?
         b.   It was her longtime friend from Maine that Sally resolved after
                 much consternation to give her mother's gold bracelet to.

Occasionally this contrast shows up even in simple sentences (as noted by Hornstein and Weinberg):

(65)   a.   At what time did John leave?
         b.   ?*What time did John leave at?
         c.   Since when has he been like that?
         d.   ?*When has he been like that since?

Thus, the general claim in the literature, which I adopt, is that P-stranding extraction from VP-modifier PPs is ruled out (e.g., Kayne (1983) uses lack of government by V as the crucial factor; Hornstein and Weinberg (1981) refer to VP PPs versus S PPs, citing Dresher (1976) for differences between these classes), and that something odd is happening in (most of) the examples in (59). Since V-NP-PP sequences are the focus here, exceptions involving V+P will be

put aside. Pesetsky (1995) suggests that some (poorly understood subset of) modifier PPs can appear in the sister to V position as well as in their canonical adjoined position, and being in the former position allows extraction. (If this is on the right track, it constitutes a good reason for classing extraction with the non-semantic diagnostics.) He thus correctly predicts that if such a PP is forced by a VP pro-form construction not to be within V-bar, extraction from it should become bad:[22]

(66)   a.   *I know that Bill gave the book to them on Tuesday. Tell me what day Mary did on. [cf. the day that Mary left on]

         b.   I know that Bill gave the book to them on Tuesday. Tell me on which day Mary did.

         c.   *I know that Sue gave the book to them in the big garden. Tell me which garden Mary did in. [cf. a garden that Mary has given lectures in]

         d.   I know that Sue gave the book to them in the big garden. Tell me in

              which garden Mary did.

Again, pied piping is much better.

       Another environment where extraction is sensitive to argumenthood involves weak islands. As the following canonical examples show, extraction of an argument from a *wh*-clause yields only a mild Subjacency violation, whereas extraction of a modifier from the same environment yields sharp ungrammaticality, violating standard formulations of the ECP.

(67)   a.   ?What do you wonder whether Angelo fixed?

         b.   *How$_i$ do you wonder whether Angelo fixed the car t$_i$?

(68)   a.   (?)Which car do you remember how to fix?

         b.   *How$_i$ do you remember which car to fix t$_i$?

This contrast seems to extend to PPs as well:

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[22] It would obviously be useful if we could extend this hypothesis to cases of unexpected modifier extraction from NP like those in (54). Unfortunately, it appears very difficult to apply the crucial test:

(i)   a.   There are lots of cute guys visiting from all over the world right now. ??Which city did Mary meet one from?

        b.   Several foreign scholars are at this convention. ??Which country did Mary meet one from?

To make Pesetsky's argument go through, it would have to be the case that (ia and b) are substantially worse than (54a). However, if they are not, that could be because we are getting the numeral reading of *one* rather than the anaphoric reading. We can change the examples to use *the one* instead, and that seems to make them worse, but that in turn could be because of the Specificity effect.

(69) a.   ?On which shelf do you wonder whether Angelo put the book?
     b.   *On which day last week do you wonder whether John bought the book?
     c.   ?To which friend do you wonder whether John gave the book?
     d.   *In which city do you wonder whether John saw Mary?

By my intuition, this contrast becomes hazier if the prepositions are stranded:[23]

(70) a.   ?Which friend do you wonder whether John gave the book to?
     b.   ??Which city do you wonder whether John saw Mary in?

Thus, I focus on the full PP extractions. Baker (1988) notes that, as with mono-clausal PP extraction, certain apparent modifier PPs (temporals and locatives, according to him) allow fairly good extraction from weak islands, at least for some speakers:

(71) a.   (?)On which day next week do you wonder who will go to the theater?
     b.   ?In which park do you wonder whether John met Mary?

Baker cites a personal communication from Rizzi for the suggestion that temporal PPs like the one in (71) are selected by Tense/Infl, and hence behave like arguments. Alternatively, Pesetsky's proposal would directly account for these facts as well, making the additional prediction that they should get worse if a pro-form is used in the lower clause, and this seems to be correct. (Unfortunately, there is no way to compare these to argument extractions, since pro-forms cannot co-occur with arguments. Thus, sentences of the form of (72) are predicted always to be ungrammatical unless extraction from a PP in an adjunct position were possible, which it seems not to be.)

(72) a.   ??I know that lots of people were thinking about going to the theater next week. On which day (next week) do you wonder who will actually do so?
     b.   *I know that lots of people were thinking about having a picnic in various parks next week. In which park do you wonder who will actually do so?

To summarize, VP-attached PPs apparently differ from NP-attached PPs in one critical respect: under pied piping, they show no argument/nonargument asymmetry for local extractions, presumably because V is a proper governor for

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[23] I have a strong hunch that the difference between (69d) and (70b) is due to processing factors. (It seems to go in the wrong direction from a purely syntactic point of view.) Specifically, it feels as if the search for an attachment site for the trace position of the *wh*-phrase is delayed in (70b) until a potential theta-assigner for the *wh*-phrase is encountered, which does not happen until inside the lower clause, and this somehow makes the island violation less apparent. In contrast, in (69d) the search for a trace position seems to start immediately, since the PP does not need a licensing theta-assigner, so the fact that this search crosses the boundary of a [+wh] clause is much more salient. I hope to explore this possibility experimentally in the future.

these PPs. Under preposition stranding, there is an asymmetry, presumably because the PP node itself then becomes a relevant bounding node, but it is somewhat obscured in simple sentences. The solution for present purposes is to test complex constructions and/or to test in VP pro-form clauses, for verbs that allow *do so* replacement. There is also an asymmetry under extraction from weak islands, though again certain modifiers pattern like arguments under this test. The contrast seems crisper under pied piping, but can be quite subtle even there. Therefore, I suggest that weak island extractions be used only as confirmation for other tests; a negative result can be taken to support nonargumenthood, but a positive result could be misleading.

Before concluding this section it must be pointed out that there is a well-known class of apparent exceptions to two of the noun argument tests (noted in Jackendoff 1977), namely *picture*-type nouns. In (73) I lay out the diagnostics as applied to such a noun:

(73) a.   *a picture of trees, of maples
      b.   a picture that was of Sandy; This photograph is of my mother.
      c.   the picture of Kim and the one of Sandy
      d.   *a photograph from John of me [cf. a photograph of me from John]
      e.   Which woman did you see a picture of?

On the face of it, (73a, d, and e) indicate argumenthood while (b) and (c) indicate modifierhood. But notice that (b) and (c) are the tests that are built around the predicative nature of modifiers, while the other tests are based on properties of arguments. Thus, a potential response to this paradox (e.g., Gazdar et al. 1985) is to claim that *of* can actually carry semantic content, meaning roughly 'depicting', and (b) and (c) rely upon predicating the property 'depicting X' of the noun.[24] The problem with this approach is that if a modifier reading of *of* is generally available, it ought to allow (73a) and (73d) to be good as well. I am not aware of any proposed solutions to this problem, so I can do no more than alert the reader to it.

2.3   Some false and/or unhelpful diagnostics

In the category of more syntactic potential tests for argumenthood, there are some phenomena that might appear to be sensitive to argumenthood, and that have sometimes been suggested as diagnostics, but which on closer examination actually seem not to bear on it. The restrictions involved in these constructions are poorly understood, for the most part, and I do not propose analyses of them;

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[24] Gazdar et al. also suggest that semantically, a photograph is not necessarily *of* anything at all (e.g., if it is underexposed), so there is no semantic entailment of the argument, unlike a relational noun like *sister*, which does not pass any modifier tests: *the sister who is of John, *the sister of John and the one of Susan*. This contrast shows that the exceptional behaviour in (73) is not a general property of *of*, but does seem to depend either on the noun to which it attaches or on some nonrelational semantic content.

all I attempt to do here is to illustrate that there are reasons to seriously doubt that any of them are useful as diagnostics in the context of this study.

2.3.1 Extraposition

It has been suggested by Radford (1988) that if a PP can extrapose rightward from an NP then the PP is *not* an argument of the head noun; arguments cannot extrapose. Initial support for this idea comes from contrasts like (74) versus (75):

(74) a. A student came to see me yesterday with long hair.
     b. Men appeared from Tanzania.
     c. A Martian walked in with long antennae.

(75) a. *A student came to see me yesterday of physics.
     b. *A member left of the committee.
     c. *A side was broken of the box.
     d. *A pound was sold of apples.

However, there seem to be many counterexamples to this generalization in both directions. Most importantly in the present context, some PPs that are clearly arguments by other criteria extrapose perfectly easily (some of these examples are from Jackendoff 1977, Rochemont & Culicover 1990, and from Radford himself):

(76) a. A review has just appeared of my latest book.
     b. A solution was proposed yesterday to that problem.
     c. A photograph was published last year of a man with three arms.
     d. The mayor just called you of a large Eastern city.
     e. The destruction was ordered of a new bridge from Italy to Boston.
     f. A request was received for eighteen more copies of MITWPL 26.
     g. A problem emerged last week with the new design specifications.

As is more widely acknowledged in the literature, there are also many instances where extraposing a modifier is ungrammatical:

(77) a. *A man whispered with blond hair.
     b. *A man hit me from Paris.
     c. *A man was killed from Germany.
     d. *A puppy disappeared with big, cute ears.

Thus, whatever extraposition is sensitive to, argumenthood does not seem to be it. This is not surprising, given that extraposition of argument *clauses* from NP is clearly possible:

(78) a. The claim was made that the witness was a liar.
     b. The fact emerged that John had no alibi.

The identification of factors actually involved in the possibility of extraposition has been difficult. Clearly, the nature of the main predicate of the sentence is relevant (79), and heaviness seems to matter (80), suggesting that focus is at play here:

(79) a.   A book appeared by Chomsky.
      b.   *A book fell by Chomsky.

(80) a.   ?A bottle was sent of that marvelous French perfume.
      b.   ?*A bottle was sent late last night of perfume.

The reader is referred to Guéron 1980, Takami and Kuno 1992, Rochemont and Culicover 1990, and Akmajian and Lehrer 1976 for some hypotheses and discussion. Obviously, we would like to know what rules out examples like those in (75), if not argumenthood, especially since the main predicates in these examples do seem to allow extraposition in general. Akmajian and Lehrer note that "certain partitive constructions" seem to resist extraposition (see Selkirk 1977 for additional discussion); this might cover cases like (75c–d), but it does not seem to extend to (75a), and seems to be contradicted by (80a). However, it is probably not a coincidence that all the nouns in (75) are highly relational, whereas most of those in (76) and (80) need not be.[25]

2.3.2   PP-preposing

Chomsky (1965) noted the following contrasts, which seem to show that argument PPs cannot be preposed while modifier PPs can:[26]

(81) a.   At the office, he worked.
      b.   At ten o'clock, he laughed.
      c.   After dinner, he ran.

(82) a.   *At the job, he worked.
      b.   *At the clown, he laughed.
      c.   *After John, he ran.

One might think that this is really a reflection of the preposition being reanalyzed as part of the verb and hence not being separable from it, but this contrast seems to extend to cases where a direct object intervenes:

(83) a.   On Tuesday, John mailed the letter.
      b.   *To Mary, John mailed the letter.

However, as has been noted in the literature (see Brunson 1992 for a survey), argumenthood seems not to be the major factor here (but see Hornstein and

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[25] I thank Colin Phillips for discussions on this point.

[26] The ungrammatical sentences have (dispreferred) readings where the PPs are taken as modifiers; at issue are the readings where the verb + preposition forms a semantic unit, e.g., *work at, laugh at, run after*.

Weinberg's (1981) discussion of Dresher 1976 for a seemingly opposing viewpoint). Preposed arguments improve when they are heavier and when the remainder of the VP is heavier, especially when the PP is not separated from the rest of the sentence by a pause; this suggests that focus might be relevant.

(84) a.   To the old woman John mailed the letter.
      b.   To Mary, John mailed a large red package that contained her
            birthday present.
      c.   ?On the table John put the book.

(Incidentally, heaviness does not seem to improve the examples in (82) at all, suggesting that reanalysis might indeed be the right account of those cases.) Thus, while modifiers might be preposable with fewer restrictions than arguments, PP argument preposing is certainly not impossible.[27] It might turn out that the impression that argument preposing has more specific focus requirements than modifier preposing is valid and important, but in the absence of an explanation for why that should be the case, and in the absence of reliable ways to distinguish marked from unmarked patterns of focal stress, I avoid using this as a diagnostic for argumenthood.

2.3.3   Quantifier scope

Jackendoff (1977) notes some examples inspired by Lakoff (1970b) wherein the potential scope of a quantifier in an NP-internal PP seems to vary as a function of whether that PP is an argument of the N:

(85) a.   Fathers of few children have any fun.
      b.   *Fathers with few children have any fun.

(86) a.   Arguments with few people yield any satisfaction.
      b.   ?*Arguments with few premises yield any satisfaction.

The claim is that *few* can scope out of an argument PP high enough to license the negative polarity item (NPI) in the object, but it cannot scope far enough out of a modifier PP. Another way to look at this might be that there are two words *few* with different properties, only one of which (somehow) licenses NPIs, and that one is blocked from appearing in a modifier (Colin Phillips p. c.).

Subsequent investigation seems to have led to the conclusion that scoping out of NPs is generally possible, and that some more specific factor than

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[27] Jackendoff (1977) suggests that this contrast separates arguments versus modifiers of adjectives, citing the following kind of example:

(i)   a.   For our hero, it was unfortunate that Rome burned.
      b.   ?*On Fred, Bill is dependent.

My intuition is that cases like (ib) also improve with heaviness: *On his nextdoor neighbour John is dependent for food in times of crisis* sounds OK with suitable stress placement. The fact that this contrast in apparent focus requirements obtains across categories is surely not coincidental.

nonargumenthood is responsible for the failure of the bad examples in (85) and (86). Thus, the examples in (87) are fine although the PPs are not arguments by other tests.

(87) a. Someone in every city voted for Debs.
b. People from every walk of life like jazz.

Notice that the quantifier *every* must scope out of the NP to get the correct interpretation: no single person is from every walk of life or in every city, so the sentence (87b) must mean something like 'For every walk of life x, there are people from x who like jazz.'

Based just on the contrast between (85b, 86b) and (87), there are two places to look for an explanation: the identity of the quantifier (*every* versus *few*) and the identity of the preposition (*with* versus *of/in/from*). Heim (1987) takes the latter approach, arguing that "possessive" uses of *with* have certain peculiar semantic properties that would independently predict the badness of wide scope in examples like (85b, 86b). We should then expect that wide scope out of modifiers headed with all other prepositions is fine. However, examples like the following seem to be somewhat degraded:[28]

(88) a. ??Computers from few mail-order companies have any defects.
b. ??Books from few libraries have any torn pages.
c. ??Books in few campus bookstores have any pictures.

Thus, the problem might actually be that there are obscure restrictions on wide scope readings of *few*. However, argumenthood does not seem to be systematically one of them, since there is little if any contrast in the following pair:

(89) a. Governors of few states have any desire to pass this legislation.
b. Senators from few states have any desire to pass this legislation.

I have no analysis to propose here, but the status of this test seems to me quite uncertain.

2.3.4   Entailment

Dowty (1982) proposes an entailment test for argumenthood. He suggests that *I sold the house* entails that you sold it to someone, but *I baked the cake* does not entail that you baked it for someone, so the goal phrase of *sell* is an argument but a beneficiary is not. Putting aside the potential difficulty in ascertaining whether something is entailed (e.g., whether *I broke the window* entails the use of some instrument, possibly including a part of one's own body), Bresnan (1982) has argued against this diagnostic on principled grounds. She

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[28] However, Gibson (personal communication) finds the following perfect:

(i)   Computers from few mail order companies come with any extra memory chips.

claims that the occurrence of any event entails that it occurred at some time, at some place, and in some manner, so that we should be forced to conclude that temporal, locative, and manner adverbials are almost always arguments, which on all other grounds they seem not to be. Perhaps Dowty's idea could be maintained by saying that these are actually arguments, not of the verb, but of an event-related functional head in the Infl complex. The point here is simply that it is not obvious how to make an entailment test draw roughly the line that we are trying to draw.

2.3.5 *Shared argument structure of N and V*

Radford (1988) implies that argument-taking properties of verbs can be used to help decide argument-taking properties of morphologically related nouns. For instance, in (91a) the PP is an argument, corresponding semantically to the direct object of (90a), but there is no argument of the verb *study* to which the PP in (91b) corresponds.

(90)   a.   He is studying physics.
       b.   He is studying long hair.

(91)   a.   He is a student of physics. [= (90a)]
       b.   He is a student with long hair.

The underlying assumptions here are that direct objects of verbs are always arguments and that the *of*-complement of a noun stands in the same semantic relationship to it as a direct object of a verb does to that verb. The point might be mostly valid yet uninformative with respect to *of*-complements, which typically show many other argument properties anyway, but things become trickier in other cases, for example,

(92)   a.   I desire (*for) a solution.
       b.   my desire for/*of a solution

Similarly, one might suggest that if a verb takes a *PP*-complement with argument properties and a related noun takes a PP headed by the same preposition then it is probably an argument too. However, there is a great deal of literature that is at pains to point out that the argument structure of verbs and related nouns is generally not the same; see, among many others, Rappaport 1983, Abney 1987, and Grimshaw 1990. I conclude that there is no basis to expect this test to be valid, at least in its naive form.

2.3.6 *The Culicover and Wilkins tests*

Culicover and Wilkins (1984) have proposed a set of tests for diagnosing the internal constituency of VP, and these tests have sometimes been claimed as argumenthood tests (Radford 1988). At least in the sense of "argument" relevant here, however, they are not. Culicover and Wilkins describe the tests as distinguishing two constituents, which they label V^1 and V^2: "The constituents occurring inside V^1 are those that are obligatorily strictly subcate-

gorized (as the PP that co-occurs with *put*) and those that are directly assigned thematic roles by the verb. Although a constituent immediately dominated by V^2 might bear a thematic role, the particular role is not assigned directly by the verb, but rather (at least in English) by a preposition (as in 'goal' indirect objects governed by *to* or 'benefactive' indirect objects governed by *for*)." Thus, Culicover and Wilkins do not wish to analyze goal *to*-phrases as arguments of the verb directly. But the cluster of properties that I have identified as those of arguments in this paper clearly hold of such phrases. Putting aside the terminological question of how to label these two notions, the important fact is that the Culicover and Wilkins tests draw a systematically different division among PPs than the tests reviewed in section 2.2. If the latter are relevant for argumenthood, as has been assumed, then the former cannot be used to rule out PPs as arguments.

The four tests are as follows.[29] 1) Subject-oriented emphatic reflexives can be inserted between the verb and a V^2 PP, but not between the verb and a V^1 PP.

(93)   a.   John wrote/gave the letter himself to Mary.
         b.   *John put the book himself on the table.

2) PPs in V^1 must be deleted by the "VP rule," while PPs in V^2 may remain:

(94)   a.   Who put the book where? *John did on the table.
         b.   Who sent the letter to who(m)? John did to Mary.

3) Gapping cannot leave behind both an NP and a PP that is in V^1, but it can leave behind an NP and a PP in V^2:

(95)   a.   *John put Fido in the doghouse, and Sam, Spot in the yard.
         b.   John gave a dog to Mary, and Sam, a cat to Susan.

4) Topicalization of a PP from V^1 cannot strand a VP adverb but must pied pipe it, while the opposite is true for a PP from V^2:

(96)   a.   *On the table, John put the book carefully.
         b.   Carefully on the table, John put the book.[30]

(97)   a.   To Mary, John gave the book carefully.
         b.   *Carefully to Mary, John gave the book.

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[29] Culicover and Wilkins mention a fifth test which is essentially the ordering test discussed in section 2.2. For independent reasons, it is not possible to apply this test to *put*- versus *give*-type PPs.

[30] The example and the judgement are Culicover and Wilkins's. I do not find either version of this example grammatical.

3.   The status of instrumentals

Before applying the diagnostics from section 2.2 to the experimental sentences, we must consider one large subclass of cases where they do not seem to be conclusive, namely with regard to instrumental PPs.[31] (See Nilsen 1973 and Brunson 1992 for review of the primary literature concerning instrumentals.) Six of Rayner et al.'s 12 sentences involved instrumentals as their VP-attachment readings. Therefore, the status of these phrases could have much to do with their results. Let us begin by considering what makes a phrase instrumental.

Fillmore (1968) defines instrumental as the case of the inanimate force or object causally involved in the action or state identified by the verb; Fillmore (1971) describes it as the immediate cause of an event. Jackendoff (1987) describes it as an intermediary between actor and patient in the decomposition of an action. A couple of heuristics have appeared in the literature for deciding whether a given expression is an instrumental. First, instrumentals are generally questioned with *how*, whereas some other uses of *with* are not:

(98)   a.   *How* did John stir the soup? He stirred the soup *with a spoon.*
        b.   ??How did John visit his parents? He visited his parents with Mary.

The problem with this test is that other kinds of *with*-phrases satisfy it also, for instance, the manner phrase in (99):

(99)   *How* did John open the box? He opened the box *with care.*

A second test is whether the *with*-phrase can be paraphrased with the verb *use*:

(100) a.   John stirred the soup with a spoon.
        b.   John used a spoon to stir the soup.

But this is not foolproof either, as Nilsen (1973) shows.[32] One other test depends on already having established one phrase as an instrumental, then using it to test a second phrase. Since phrases with different semantic roles cannot generally be conjoined except for special pragmatic or stylistic effect (e.g., Fillmore 1968), the examples (101a) and (101b) show that *with John* and *with care* are not instrumentals, while (101c and d) contain phrases that are:

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[31] Instrumentals are by no means the only unclear cases. Comitatives (e.g., *John toured the house **with Mary***) seem to show similarly equivocal behavior. However, the number of sentences in the experimental literature that have a potential comitative reading that do not also have a potential instrumental reading is quite small, so I do not attempt to ascertain their status here.

[32] For instance, the paraphrase is sometimes blocked for independent reasons:
(i)   a.   John killed the bully with a single bullet.
        b.   *John used a single bullet to kill the bully.
(ii)   a.   John (accidentally) cut his finger with a knife.
        b.   *John used a knife to cut his finger. [can only be taken as volitional]

(101) a.　　*He robbed the bank with John and a sawed-off shotgun.
　　　b.　　*The doctor examined the patient with care and a rubber mallet.
　　　c.　　The doctor examined the patient with a stethoscope and rubber mallet.
　　　d.　　The landlord painted the walls with a roller and latex paint.[33]

Having at least some notion of how to identify instrumentals, let us consider their thematic status.

　　　Abney (1989) implicitly assumes that instrumentals are arguments, but he does not argue for this claim. However, in recent work Sedivy and Spivey-Knowlton (1994; Spivey-Knowlton & Sedivy 1995) claim that argumenthood can*not* explain a preference they found for VP-attachment of *with*-PPs, because instruments are not arguments.[34] Their evidence against instrumentals being arguments is as follows: 1) they can co-occur with VP pro-forms, as noted by Lakoff and Ross (1976 [1966]) (102); 2) they can be ordered after modifiers (103); 3) they allow emphatic reflexive insertion (104); 4) they are not restricted in their occurrence; and 5) their relationship to an event is constant regardless of the particular verb (citing Dowty 1982).

(102) a.　　Sue stirred the soup with a spoon, but Fred did so with a fork.
　　　b.　　What John did with the knife was cut the bread.

(103)　　　John will break the door down on Tuesday with a crowbar.

(104) a.　　John will eat the cake himself with a fork.
　　　b.　　*John will place the book himself on the shelf.

I argue that these points are not conclusive. We have already seen that emphatic reflexive insertion is not a valid test for argumenthood. Let us consider the other claims in more detail. I first consider the semantic evidence (points 4 and 5), then the syntactic evidence (points 1 and 2).

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[33] Note that examples (101c and d) illustrate that the two objects need not be used identically in the action described by the verb: one presumably listens through a stethoscope but strikes the patient's knee with a rubber mallet, and similarly for a roller and paint. Nonetheless, they seem to form a natural class.

[34] Spivey-Knowlton and Sedivy (1995) report two experiments involving the attachment of *with*-PPs, one using "action verbs," which found a consistent VP-attachment preference, and one using "psychological predicates and verbs of perception," which found an NP-attachment preference when the direct object was indefinite. While the authors acknowledge that these verb classes differ in that only the former systematically allows instrumental uses of *with*, they deny the relevance of argumenthood to this effect because they claim that instrumentals are not arguments. If, as I argue, instrumentals actually *do* have argument properties, the contrast they found would be explained by an argument preference, which would favour VP-attachment for instrumental uses of *with* but not for modifier uses.

The semantic points boil down to the simple question of whether instrumental phrases meet one of the semantic criteria for argumenthood discussed in section 2.1, namely, dependence on a head: Can the *with*-phrase occur only with heads that specifically license it, and does its interpretation depend on the identity of that head? Dowty (1982) claims that one can add instrumental, benefactive, and locative phrases to virtually any verb, regardless of valence, and in sentences containing these elements, their meaning could have been complete without it, that is, the presence of an instrumental, etc., is not entailed by the meaning of the predicate. The problems with entailment vis-à-vis argumenthood were discussed in section 2.3.4, so I concentrate here on the claim about distribution. We should also ask about the other purported criterion for argumenthood: Does the *with*-phrase predicate a property or does it fill a role in the relation described by the verb? I attempt to address both of these admittedly fuzzy issues below.

First, we should establish the facts concerning the distribution of *with*-PPs. The usual description in the literature is that instrumentals can occur only with propositions containing an agent, either expressed or implied. The standard paradigm that allegedly demonstrates this is the following:

(105) a.   John broke the window with a rock.
      b.   The window was broken with a rock.
      c.   *The window broke with a rock.

The idea is that John is the agent in (105a), that there is an implicit agent in passives (105b), but there is no implicit agent in inchoatives, hence the ungrammaticality of (105c). However, (105c) could also be argued to violate an independent constraint: instrumentals appear to be higher on the thematic hierarchy than themes, which means that in a sentence with no agent, the instrumental must become the subject (Nilsen 1973). Indeed, exactly that happens in (106):[35]

(106)   A rock broke the window.

There is no evidence for an implicit agent in (106): in fact, this sentence can be used in a context where no volition was involved in the rock's breaking the window.

Another kind of example intended to show the agent requirement is shown in (107) (from Gruber 1965):

(107) a.   *John lost the book to Bill with bad luck.
      b.   *The boat floated on the surface of the water with an inflated tube.

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[35] One might ask how we know that the subject of (106) is indeed an instrumental, given the absence of *with*. One argument is that the other obvious possibility, namely that it is an agent, seems to be disproved by the badness of examples like *John and a hammer broke the window*; by Fillmore's (1968) conjunction test, instances of the same role ought to be conjoinable (cf. *John and Mary broke the window, A rock and a branch broke the window*).

      c.   *The water flowed with locks.
      d.   *The blood coursed through his veins with a heart pump.

Here, the argument does seem to go through: the only thing wrong with these sentences seems to be that their subjects are not acting volitionally. Indeed, Gruber claims that if the action is conceived of as involving an implicit agent, then the instrumentals are allowed even when the subject is not the one acting volitionally:

(108) a.   The water finally flowed smoothly with a proper arrangement of locks.
       b.   John finally went through the slightly too small hole with a shove.
       c.   The nail came away from the wall with the back of a hammer.

Notice that in these cases, it is not the subject that is taken as the user of the instrument, but rather, someone unspecified, because the subject is not an agent of the main predicate. In contrast, when the subject is the agent, then an instrumental must associate with it: this can be seen most easily by contrasting (108b), where someone else shoves John, with (109), which has to mean that John did the pushing himself.

(109)   John dove into the ocean with a push.

The same seems to be true of middles, which allow instrumentals despite lacking agents: the subject cannot be construed as the user of the instrument.

(110) a.   This vase will break easily with a hammer.
       b.   John bruises easily with rocks.

     Thus, a (nonsubject) *with*-instrumental seems to depend on a volitional agent being at least implicated in the situation being described, though not necessarily syntactically present in the sentence;[36] a subject (bare-NP) instrumental seems to lack this restriction. While the exact characterization of these facts might elude us,[37] it is clear that the distribution of instrumentals depends on semantic properties of the predicate with which it co-occurs. This differentiates it from canonical modifiers like *on Tuesday*, but it must be acknowledged that

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[36] Additionally, Lakoff (1968) claims that instrumentals can be used only with activity verbs:

(i)   *Albert knew the answer with a sliderule.

However, the stativity of *know* in (i) seems less relevant than the lack of volition on the part of the subject, given that the following nonstative predicates also disallow instrumentals (in fact, I cannot even suggest how the sentences might be completed with anything like an instrumental):

(ii) a.   John fell with . . .
      b.   John died with . . .

[37] Brunson (1992) reviews most of this data and concludes that the constraint is simply that instrumentals occur only with predicates that assign a cause role.

other types of modifiers are restricted by predicate type too, for instance, adverbs like *deliberately* and PPs like *for three hours*. My assessment, then, is that these facts are inconclusive, but certainly do not support the claim that the distribution of instrumentals is free.

What about the question of whether the interpretation of the *with*-phrase depends on the verb? Dowty (1994) himself identifies a range of interpretations that *with*-phrases can receive, exemplified in (111).

(111) a.   record the event with a video camera
            sight the bird with a telescope
            solve the problem with ingenuity [no entailment that instrument changes position]

      b.   hit the nail with a hammer
            sweep the floor with a broom
            crack open the safe with a crowbar [instrument moves, but not to a specific endpoint]

      c.   fasten the picture with nails
            enrich the soil with fertilizer
            weight the ship's hold with rocks [instrument ends up in a specific position]

      d.   fill the glass with wine
            cover the table with books
            [instrument has higher degree of affectedness, often comparable to direct object]

The implicational differences noted in brackets clearly depend on the main predicate, not on the contents of the PP: one could replace *hammer* with *video camera* in (111b) and movement of the camera would then be implied.

Perhaps a stronger case for semantic dependence is made by Marantz (1984), on the basis of contrasts like the following:

(112) a.   Elmer unlocked the porcupine cage with a key.
      b.   Elmer examined the inscription with the magnifying glass.

(113) a.   A key unlocked the cage.
      b.   *The magnifying glass examined the inscription.

Marantz notes that in (112a) a key is an intermediary "agent" in the act of unlocking: Elmer does something to the key, the key does something to the cage, and the cage unlocks. By contrast, in (112b) the magnifying glass is not an intermediary agent but merely a tool required to complete the action of examining. This contrast in meaning does not emerge from considering the PPs in isolation, but depends crucially on the main predicate. As Marantz points out, this distinction correlates with the possibility of using the instrument as a subject, as

shown in (113), which suggests that this is not simply a matter of pragmatic inference (see also Fillmore 1971).[38] Thus, the evidence on this point is fairly conclusive: instrumentals are like arguments in depending on another element for their interpretation.

Let us turn briefly now to the third aspect of the semantic question, namely, the status of an instrumental as predicate versus role-filler. I cannot argue against the *with*-phrase being a predicate, but it might be possible to argue for it filling a role. Brunson (1992) suggests that Agent and Instrument are both manifestations of the more fundamental role Cause. (In her terminology, they are "disconstituents.") This gives instrumentals a unique status as *part of* an argument relation but potentially not the only part that is expressed in the sentence. Such a view seems to make sense of many of the properties of instrumentals, as we will see.

Returning to Sedivy and Spivey-Knowlton's syntactic arguments, the observations seem to be correct: (103) still sounds fine with emphasis on *Tuesday*, indicating that the sentence-final position of the *with*-phrase is not dependent on focus, and instrumentals can clearly co-occur with VP pro-forms, as in (102). Recall that I provisionally classified both of these as syntactic diagnostics in section 2.2, in the sense that it is not obvious from the definition of an argument why these tests should bear on argumenthood. Indeed, we already know that the ordering generalization has systematic exceptions. As for *do so*, suppose we pursue the suggestion above that the element that it replaces has to be "complete" or "interpretable" (perhaps it must have no unfilled internal arguments). Combining this with Brunson's idea, we can explain (102) by noting that the proposition *Fred stirred the soup* is complete, that is, no theta-roles are open, because the agent already expresses the (obligatory) cause role.[39] Therefore, the sentence is grammatical.

What about the other syntactic diagnostics, which Sedivy and Spivey-Knowlton do not mention? As for iterativity, instruments generally come out as arguments on this test (as observed by Lakoff (1968)):

(114) a. *Mary cut the meat with a tool with a saw.
      b. *John cut the meat with a knife with the sharp end.

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[38] Furthermore, to the extent that the interpretation of *a key* is the same in (113a) as in (112a), this interpretation clearly must depend on the verb and not just on the preposition *with*, since *with* is absent from (113a). In fact, Tremblay (1995) argues that *with* has no semantic content anyway. Marantz gives another argument to support this conclusion as well. He points out that crosslinguistically, the adposition that marks instrumentals often marks comitatives and/or *by*-phrases as well, and in the latter two instances it is clear that the roles received by these phrases are not determined by the adposition but by the main predicate of the sentence.

[39] Another way of looking at this is to say that *do so* obligatorily replaces all *internal* arguments, so the instrumental is spared because it is part of the *external* argument.

    c.   *John painted the wall with a paintbrush with the ends of the bristles.

The restriction on multiple instrumentals continues to hold when one of them is a subject, as Lakoff notes:

(115) a.   *The explosion killed Harry with dynamite.
        b.   *The blow-torch heated the food with a low flame.
        c.   *Air pollution killed my petunias with cyanide.

Bresnan (1982) concludes from such facts that instrumentals should be treated as arguments.

      However, Brunson (1992) points out that there are some pathological exceptions:

(116) a.   Mary wrote the essay with her right hand with a pencil.[40]
        b.   John stirred the soup with his right hand with a spoon.
        c.   I wrote this paper with my computer with Microsoft Word.
        d.   ?Heather opened the rusty lock with a key, with a pair of pliers.[41]

It seems to be characteristic of these exceptions that the two *with*-phrases to not play the same role in the action: for instance, in (116a) her right hand does not itself make marks on paper; in (116b) his right hand does not directly touch the soup (as witnessed by its non-synonymy with *John stirred the soup with his right hand and a spoon*). This is further confirmed by the possibility of making one of these phrases the subject, even though it is not the immediate cause:

(117)   His right hand stirred the soup with a spoon (while his left hand held the baby's bottle).

Thus, these apparent exceptions to non-iterativity do not undermine the argument status of instrumentals.[42] The only thing unusual about examples like those in (116) as far as arguments go is that certain predicates can license more

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[40] Brunson (1992) attributes this example to Judith Cowper Szamosi.

[41] Pollard and Sag (1987) consider this example grammatical; unlike the others, it does not seem very good to me.

[42] An important difference in behaviour between the iterated instrumentals in (116) versus iterated modifiers of a given type, e.g., temporals in (i), is that only the latter are subject to an ordering constraint. Thus, (iib) is bad, but both examples in (iii) are fine:

(i)   He met Jane last week on Tuesday at 3 o'clock just after she got off work.
(ii) a.   On Tuesday, John met Mary at 3 o'clock.
       b.   *At 3 o'clock, John met Mary on Tuesday.
(iii) a.   With a spoon, John stirred the soup with his right hand.
       b.   With his right hand, John stirred the soup with a spoon.

than one instrumental role to express different aspects of the action. It is still the case that only one syntactic realization of each such role is possible:

(118) a.   *I wrote this paper with a computer with my Macintosh Quadra.
      b.   *I wrote this paper with a word processor with Microsoft Word with version 5.1.

I conclude that instrumentals pattern with arguments on the iterativity test.

The final syntactic test we need to consider is extraction. Baker (1988: 243) explicitly argues for the argument status of instrumentals on the basis of the following (b) versus (c) weak island extraction contrasts, where (c) represents a canonical modifier extraction:

(119) a.   I always forget to open doors with this key by flicking my wrist.
      b. (?)With which key do you always forget how to open doors?
      c.   *How do you always forget with which key to open doors?

(120) a.   I know to seal these cans with a hammer by tapping lightly on their tops.
      b. (?)With what do you wonder how to seal paint cans?
      c.   *How do you wonder what to seal paint cans with?

The extraction continues to be reasonably acceptable when the verb is replaced by a pro-form:

(121) a.   I know that lots of people were hoping to unlock this door with various keys. ?With which key do you wonder who will actually do so?

      b.   I know that several construction workers were planning to repair the house with various tools. With which tool do you wonder who will actually do so?

Instrumentals also allow direct preposition stranding in complex constructions where it is generally degraded for modifiers:

(122)   This flimsy key is extremely hard to convince yourself to be willing to open such a heavy door with.

Local extraction is also possible with a VP pro-form.

(123)   I know that Bill fixed the fan with a hammer. Tell me which tool Mary did so with.

Thus, instrumentals pattern with arguments for extraction.[43]

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[43] The interpretation of these facts is not entirely straightforward, given the parallel grammaticality of a locative that seems in other respects to be a modifier

To sum up, there are some syntactic tests and some semantic tests according to which instrumentals are arguments. There are also some syntactic tests that indicate the opposite, and there are some equivocal semantic tests, but there are no semantic tests that favour modifier status. If argumenthood is fundamentally a semantic notion, and neither the *do so* test nor the ordering test have a clear semantic basis (unlike the iterativity test), then in a forced-choice situation it is reasonable to conclude that instrumentals are arguments. However, for present purposes a weaker conclusion will suffice, namely that instrumentals clearly have several argument properties. Thus, under a version of Abney's algorithm that admits of degrees of argumenthood, they will still be driven to attach to VP whenever the competing NP attachment is a pure modifier, as it is in most of the sentences that have been tested. Given this conclusion about instrumentals, we can proceed to an overall assessment of the previous experimental results.

4. Reanalysis of previous experiments

In this section, I undertake a detailed analysis of the experiments conducted by Rayner et al. (1983), Taraban and McClelland (1988), and Clifton et al. (1991). I use the diagnostics from section 2.2 to show that their stimuli were confounded by differences between argument and modifier attachment, and that this factor alone could account for many of the findings, if the human parser prefers to attach PPs as arguments rather than as modifiers wherever possible. These experiments therefore have little to say about a purely structural attachment preference. For space reasons, I do not discuss the application of every diagnostic to every sentence; I concentrate on establishing the crucial claim of argument status wherever it holds; the reader is invited to verify that all PPs not expressly discussed are modifiers.

4.1 Rayner et al. 1983

Let us first consider sentences from Rayner et al.'s Experiment 2. Below I list the crucial portions of their stimulus pairs (omitting material that followed the noun filler and concentrating on the short versions of the PPs); the (a) completion is always intended to be VP-attached, the (b) completion NP-attached.

(i)   a.   In which chair do you know how to sit comfortably?
        b.   In which chair does Mary know how to do so?
        c.   This orthopedic chair was not particularly difficult to manage to sit comfortably in.

Baker (p. 244) suggests that this locative is really an argument (an "inner locative," in contrast to "outer locatives"); he does not show that outer locatives fail this extraction test, but as he would predict, (iia and b) at least seem significantly worse to me.

(ii)   a.   ??In which city$_i$ does the agent know how to meet his contact t_i?
        b.   ?*In which city$_i$ does his partner know how to do so t_i?
        c.   ?This city proved to be rather challenging for the secret agents to manage to meet their contacts in.

(R1)   The spy saw the cop with (a) binoculars (b) a revolver.
(R2)   The little girl tried to cut the apple with plastic (a) knives (b) coating.
(R3)   The landlord painted all the walls with (a) enamel (b) cracks.
(R4)   John played the records with (a) Jim's needle (b) deep scratches.
(R5)   Jane finally decided to read the books on the (a) train (b) list.
(R6)   The overworked scientist only read the news reports on (a) Sundays
         (b) tornados.
(R7)   The executive only called people on the (a) intercom (b) payroll.
(R8)   The kids played all the albums on the (a) stereo (b) shelf.
(R9)   Grandmother didn't see any articles on (a) the flight (b) Jupiter.
(R10)   Grandfather could only read the numbers in bright (a) rooms (b) colors.
(R11)   That kid hit the girl with a (a) whip (b) wart.
(R12)   The doctor examined the patient with a (a) stethoscope (b) toothache.

Recall that Rayner et al. found an overall preference for VP attachment with these stimuli, as indicated by longer reading times in the region beginning at the noun filler in the (b) sentences. Thus, these results could be explained by thematic factors if in most sentence pairs, the VP-attachment represents a possible argument attachment while the NP attachment represents a modifier attachment.

Table 1 indicates the results of applying the diagnostics from section 2.2 to these sentences and notes the definiteness of the direct object (see below). In the many instances of VP argument attachment that involved instrumentals, this has been noted as "(inst)" in the relevant cell; where a PP passes some but not all argument tests, this is noted as "argument?". Considering first the NP-attachments, none of these give strong evidence for argumenthood, and most of them are modifiers according to all diagnostics. The exceptions are (R6) and (R9). They are part of a larger class of nouns describing written materials about (on) some topic that display only marginal argument properties, as follows. The use of *on* in this nonlocative meaning seems to be completely productive across nouns that can be on/about some subject matter (e.g., a speech, a pamphlet, a debate). These nouns marginally allow iteration of the PP:

(124) a.   (?)Many people read the reports on the trial on Judge Ito.
      b.   (?)Scientists studied the article on Jupiter on its mineral content.
      c.   (?)I just skimmed a book on sentence processing on the garden path
              theory.

They marginally allow a relative clause paraphrase and a main clause copular paraphrase:

(125) a.   ??the report (that) was on the trial
      b.   the magazine article (that) was on new ways to lose weight
      c.   ?the book (that) was on the history of science

They allow *one*-replacement:

(126) a.   John read the news reports on tornados, and Mary read the ones on
              earthquakes.

    b.   John read the article on cooking, and Mary read the one on fitness.
    c.   John bought a book on tennis, and Mary bought one on basketball.

They can be preceded by modifiers:

(127) a.   ?The President studied a report on his DESK on Bosnia.
        b.   I read an article in the NEWSPAPER on transit safety.
        c.   No one wanted to buy a book by Carl SAGAN on linguistics.

However, they marginally allow *wh*-extraction in complex constructions and with pied piping:

(128) a.   ?Which topic did the President study a complex, technically detailed report on?
        b.   ?On which topic did the President study a report?

        c.   Which diet did you read a 20-page full-color article on?
        d.   ??On which diet did you see a new article?

        e.   ?Which subject were the students required to buy a ridiculously overpriced paperback book on?
        f.   ?On which branch of mathematics were the students required to buy a book?

Thus, these items pattern much more like modifiers than like arguments.

      Turning to the VP attachments, we see in Table 1 that six of them involve instrumental roles. (R5), (R6), (R9), and (R10) involve modifiers by all tests. (R7) and (R8) require more discussion. Note that semantically the *on*-phrase is an instrumental in both cases; the diagnostics are equivocal here. The examples do not allow iteration (though the pragmatics of (R7) makes it hard to construct a relevant example):

(129) a.   (?)The executive called his secretary on the intercom on line 1.
        b.   ??Let's play the CD on the living room stereo on the multi-disc CD player.

They sound reasonable under *do so* ellipsis but bad under pseudo-clefting:[44]

(130) a.   (?)I called Janis on the intercom and Mark did so on the telephone.
        b.   ?*What I did on the intercom was call Janis.

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[44] The contrasts in (130) are quite striking, and seem to suggest that these two tests are not equivalent. The problem with the bad pseudocleft examples seems to be that the PP is implied to modify the subject, whereas when *do* is preceded by its antecedent VP, the PP seems able to modify just the action. It is unclear to me whether this is a parsing effect or a grammatical effect.

     c.   I played the CD on the boombox and Mark did so on the big stereo.

     d.   ?*What I did on the record player was play the old albums.

They allow modifier insertion:

(131) a.   The secretary called the manager this MORNING on the intercom.

        b.   The DJ played oldies all night LONG on the record player.

They allow extraction:

(132) a.   On which intercom did the secretary call the manager?

        b.   Which intercom was the secretary hesitant to try to call the manager on?

        c.   ?On which intercom did you wonder how to call the manager?

        d.   On which tape deck did John play his new cassette?

        e.   Which CD player did John persuade Bill to try one last time to play his scratched CD on?

        f.   (?)On which turntable did John wonder how to play the old records?

Thus, as indicated in Table 1, I take (R7) and (R8) to involve somewhat argumental VP attachments.

Table 1
Attachments of Rayner et al. (1983) Experiment 2 Sentences

	Completion		
Item	VP-attached	NP-attached	Definiteness
(R1)	argument (inst)	modifier	definite
(R2)	argument (inst)	modifier	definite
(R3)	argument (inst)	modifier	definite
(R4)	argument (inst)	modifier	definite
(R5)	modifier	modifier	definite
(R6)	modifier	modifier	definite
(R7)	argument?	modifier	indefinite
(R8)	argument?	modifier	definite
(R9)	modifier	modifier	indefinite
(R10)	modifier	modifier	definite
(R11)	argument (inst)	modifier	definite
(R12)	argument (inst)	modifier	definite

In addition to the confound of argumenthood, there is another potential factor at work in the materials of this experiment (and many subsequent ones), namely definiteness. Notice that most of the examples involve a direct object with a definite determiner. There is considerable experimental evidence that restrictive modification of definite NPs is disfavoured in ambiguous sentences when there is no context to establish multiple potential referents for the head noun (Crain & Steedman 1985; Altmann & Steedman 1988; Spivey-Knowlton & Sedivy 1995; but cf. Ferreira & Clifton 1986). This tendency would thus favour VP-attached over NP-attached modifier PPs, all other things being equal. It is not known whether this preference affects argument attachments, but there is no a priori reason why it should not: argument phrases can also serve to reduce the set of potential referents of an NP (although they can also be used with nonrestrictive force). Thus, one might expect a general bias towards VP attachment in V-NP-PP ambiguities whenever the NP is definite and the PP has the same status (argument or modifier) with respect to both V and N heads. To make a prediction about the effect of this preference in NP-argument versus VP-modifier ambiguities, we need to know how it interacts with the hypothesized argument preference, a point on which there is also little evidence at this time. Because finding a VP-attachment preference with definite objects is potentially irrelevant to the issue of an argument attachment preference, I note for each stimulus sentence whether its direct object was definite.

136

In summary, we can see that 8 of the 12 sentences involved a contrast between a VP-attachment as an argument and an NP-attachment as a modifier, none of them involved the opposite—an NP-argument versus a VP-modifier, and in the remaining four, both attachments created modifiers and the object was definite in three of the four. (The processing strategy I have suggested so far makes no prediction about a choice between two modifier attachments.) Thus, overall a preference for argument attachments could explain Rayner et al.'s finding that the VP completions were easier; the effect of definiteness might also account for part or all of the results.[45]

4.2   Taraban and McClelland 1988

In contrast to Rayner et al., Taraban and McClelland's Experiment 1 found a preference for NP attachment of PPs in their new items, beginning at the word following the disambiguating noun, using word-by-word moving-window self-paced reading. (They also tested Rayner et al.'s items and replicated the VP attachment preference.) Below are the crucial portions of their sentences; again, (a) completions are VP-attached, (b) completions NP-attached.

(T1)   The thieves stole all the paintings in the (a) night (b) museum.
(T2)   The couple admired the house with a (a) friend (b) garden.
(T3)   The tourist learned the route through the (a) interpreter (b) mountains.
(T4)   The administrator announced the cuts in the (a) meeting (b) budget.
(T5)   The engineers designed the bridge over the (a) summer (b) river.
(T6)   The report described the government's programs in (a) detail
          (b) education.
(T7)   The police arrested the mastermind behind the (a) hideout (b) crimes.
(T8)   The spy had the plans for a (a) price (b) weapon.
(T9)   I read the article in the (a) bathtub (b) magazine.
(T10)   The President suggested a solution to the (a) people (b) problem.
(T11)   The corporate executive considered the issues under (a) pressure
          (b) discussion.
(T12)   The woman married the man with (a) delight (b) money.
(T13)   The doctor cured the woman with (a) penicillin (b) tuberculosis.
(T14)   The hospital admitted the patient with (a) urgency (b) cancer.
(T15)   The reporter exposed corruption in the (a) article (b) government.
(T16)   The woman flaunted the expensive ring around her (a) friends
          (b) finger.
(T17)   John ordered a pizza with (a) enthusiasm (b) pepperoni.
(T18)   The Vietnam veteran identified his old buddy from the (a) photo
          (b) war.

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[45] Although for space reasons I cannot argue the point in detail, I attribute the Minimal Attachment effects found by Ferreira and Clifton (1986), Clifton and Ferreira (1989), Britt et al. (1992), Rayner, Garrod, and Perfetti (1992), and Britt (1994) to the same factors. Analysis of the items in each of these experiments shows that i) they all contained definite direct objects; ii) all of the NP attachments were modifiers; and iii) many of the VP attachments were arguments.

For reasons of space, I do not go through the application of the diagnostics in detail (it has been conducted in the same way as the analyses described above), but simply present the results in tabular form.

Table 2
Attachments of Taraban and McClelland (1988)
Experiment 1 Sentences

| Item | Completion | | Definiteness |
	VP-attached	NP-attached	
(T1)	modifier	modifier	definite
(T2)	modifier	modifier	definite
(T3)	argument?	modifier	definite
(T4)	modifier	argument	definite
(T5)	modifier	argument	definite
(T6)	modifier	argument	definite
(T7)	modifier	argument	definite
(T8)	modifier	argument	definite
(T9)	modifier	modifier	definite
(T10)	argument	argument	indefinite
(T11)	modifier	modifier	definite
(T12)	modifier	modifier	definite
(T13)	argument (inst)	modifier	definite
(T14)	modifier	modifier	definite
(T15)	modifier	argument	indefinite
(T16)	modifier	modifier	definite
(T17)	modifier	modifier	indefinite
(T18)	modifier	modifier	definite

As Table 2 shows, there were 6 examples where an argument preference favours NP-attachment, 1 or 2 where it favours VP-attachment, and 10 or 11 where it makes no contrast. This is not a dramatic split, but it is substantially different from Rayner et al.'s materials. It is extremely unlikely that argumenthood is all that is going on here; in order for this experiment to yield an overall NP-preference (significant by items as well as subjects), the 10 or 11 noncontrasting items would have to tend towards NP-attachment for some other reason; I return to this point later. Given that almost all of the NP-argument versus VP-modifier examples involved definite direct objects, we know that *if* argumenthood is what

is relevant for those cases, it must be able to override the definiteness preference for VP attachment. The most important thing to realize about this experiment, however, as Taraban and McClelland themselves point out, is that many potential differences between the pairs of sentences were not controlled. Thus, beyond showing that these items do not immediately falsify the argument preference strategy, their results offer limited insight.

In Taraban and McClelland's second experiment they attempted to control for some of the factors that might have confounded the results of their first experiment. The critical portions of their materials are listed below, divided into VP-biased and NP-biased sentence frames. Here the (a) and (b) sentences are supposed to represent two fillers of the same role differing only in plausibility or expectedness, the (c) sentences involve a filler of a different role but still attached to the favoured head, and the (d) sentences involve attachment to the disfavoured head. The (b), (c), and (d) completions were matched for plausibility and expectedness. The relevant part of the results for our purpose is that among the VP-biased items, there was a significant increase in reading time from the (b) to the (d) completion, that is, the NP-attachment was slower, and among the NP-biased items there was also a reading time increase from (b) to (d), here indicating that the VP-attachment was slower. (These differences again manifested themselves beginning at first word following the disambiguating noun.) I would like to show that both sets of results are consistent with the argument preference hypothesis. The results of applying the diagnostics to these materials are found in Table 3.

VP-bias frames:
(T19)   We watched the magic acts with (a) amazement (b) disinterest
            (c) binoculars (d) hawks.
(T20)   The nurse undid the bandage with (a) care (b) pride (c) tweezers
            (d) adhesive.
(T21)   The conscientious researcher pursued the problem with (a) enthusiasm
            (b) dignity (c) volunteers (d) welfare.
(T22)   The little girl cut the apple with a (a) knife (b) fork (c) smirk
            (d) blemish.
(T23)   The bully hit the girl with a (a) stone (b) pillow (c) shriek (d) handicap.
(T24)   The policeman beat the suspect with a (a) club (b) newspaper
            (c) vengeance (d) scar.
(T25)   The janitor cleaned the storage area with the (a) broom (b) solvent
            (c) manager (d) odor.
(T26)   The landlord painted the wall with a (a) brush (b) ladder (c) tenant
            (d) scratch.
(T27)   The rescue crew reached the victim in (a) minutes (b) seconds
            (c) canoes (d) shock.
(T28)   The choir sang the carol on (a) Christmas (b) Hanukkah (c) demand
            (d) parchment.
(T29)   The entrepreneur used the money on (a) investments (b) stationery
            (c) vacation (d) hand.
(T30)   The police protected the prime witness from the (a) suspect (b) rain
            (c) balcony (d) rape.

NP-bias frames:

(T31)   The hospital admitted the patient with (a) cancer (b) amnesia
          (c) bodyguards (d) apologies.

(T32)   The woman married the man with the (a) money (b) trophies (c) groom
          (d) vow.

(T33)   The thieves stole all the paintings in the (a) museum (b) library
          (c) frames (d) afternoon.

(T34)   The administrator discussed the cuts in (a) spending (b) lighting
          (c) sight (d) secret.

(T35)   The executive announced the reductions in the (a) budget (b) research
          (c) future (d) evening.

(T36)   The document described the Ku Klux Klan's activities in (a) Alabama
          (b) Alaska (c) robes (d) code.

(T37)   The mayor explained his master plan for the (a) town (b) river
          (c) month (d) audience.

(T38)   The reporter destroyed the story on (a) fraud (b) God (c) tape
          (d) impulse.

(T39)   The philanthropist appreciated the story on his (a) generosity
          (b) mother (c) lap (d) deathbed.

(T40)   The manager accepted the report on (a) profits (b) workers (c) record
          (d) faith.

(T41)   The rock star co-authored the bestseller on (a) drugs (b) surfing
          (c) newsstands (d) tour.

(T42)   The high-school senior stated his goals for the (a) future (b) hour
          (c) dance (d) principal.

Table 3
Attachments of Taraban and McClelland (1988)
Experiment 2 Sentences

Item	Completion		Definiteness
	VP-attached	NP-attached	
VP-bias frames			
(T19)	modifier	modifier	definite
(T20)	modifier	modifier	definite
(T21)	modifier	modifier	definite
(T22)	argument (inst)	modifier	definite
(T23)	argument (inst)	modifier	definite
(T24)	argument (inst)	modifier	definite
(T25)	argument (inst)	modifier	definite
(T26)	argument (inst)	modifier	definite
(T27)	modifier	modifier	definite
(T28)	modifier	modifier	definite
(T29)	argument	modifier	definite
(T30)	argument	modifier	definite
NP-bias frames			
(T31)	modifier	modifier	definite
(T32)	modifier	modifier	definite
(T33)	modifier	modifier	definite
(T34)	modifier	argument	definite
(T35)	modifier	argument?	definite
(T36)	modifier	modifier	definite
(T37)	modifier	modifier	definite
(T38)	modifier	modifier	definite
(T39)	modifier	modifier	definite
(T40)	modifier	modifier	definite
(T41)	modifier	modifier	definite
(T42)	modifier	modifier?	definite

Again, the items that show a VP preference were often VP-argument attachments contrasting with NP-modifier attachments (7 out of 12), with none of the opposite type. Among the NP preference items there was a much smaller number of items with this bias (one or two), and none with the opposite bias. Thus, an argument preference strategy explains at least part of the VP-bias (T19–T30), but predicts no overall preference for items (T31–T42) and leads us to look for other reasons why the NP completions were read faster. (Again, definiteness works against NP attachment here.) It is possible that lexical priming might have accounted for many of these shorter reading times and those in Experiment 1, as suggested by Clifton and Ferreira (1989). For example, in an item like (T17), *with pepperoni* might show a faster reading time than *with enthusiasm* simply because the word *pizza* primes *pepperoni* but does not prime *enthusiasm*. Similarly, it would not be surprising if *paintings* primes *museum* more than *afternoon*, *philanthropist* primes *generosity* more than *deathbed*, and so on. In Experiment 1, substantial priming for the NP completion seems likely in (T2), (T4), (T5), (T7), (T9), (T10), (T16), and (T18); in Experiment 2, in (T33), (T34), (T35), (T37), and (T39). Thus, while the argument preference hypothesis does not in itself explain the NP preferences, it is compatible with them: when there is no argumenthood contrast among the completions, we expect other factors to show their effects.

4.3   Clifton et al. 1991

Clifton et al.'s experiments were specifically designed to test Abney's hypothesis. Each stimulus item came in four versions, to allow testing for both attachment site and argumenthood effects: VP-argument, VP-modifier, NP-argument, and NP-modifier. Since it is virtually impossible to construct four plausible minimally-differing sentences that instantiate these four completion types, two pairs of sentences were used instead, each pair being identical up to the attaching PP. One pair contrasted VP-argument and NP-modifier completions, the other NP-argument versus VP-modifier.[46] Since both the Minimal Attachment theory and Abney's theory predict a VP-preference in the former case, I focus here on the latter, where they make opposite predictions. As noted, Clifton et al. found a significant overall VP-preference, as measured in the eye-tracking experiment by average reading time throughout the disambiguating PP. They do not report comparisons of individual conditions, but it appears from examination of their means that this contrast would have been significant for the VP-modifier versus NP-argument conditions (30.1 versus 34.5 ms/char). Hence, I treat their results as a serious challenge to the claim of an argument attachment preference.

Here are the crucial portions of these items.[47]

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[46] The two pairs of sentences were sufficiently different that one cannot meaningfully compare, for instance, VP-argument versus NP-argument reading times, even though this comparison is of theoretical interest.

[47] These items are taken directly from computer files supplied by Chuck Clifton. There are slight discrepancies from the versions in the appendix of Clifton et al. 1991.

(C1)   John expressed dismay with (a) a quick gesture (b) the bad news.
(C2)   The woman showed disgust with a (a) brief glance (b) dirty baby.
(C3)   The doctor delivered a lecture on (a) Sunday afternoon (b) heart disease.
(C4)   The wife finished the arrangements with (a) relief (b) a minister.
(C5)   John continued the discussion with (a) persistence (b) the tired boys.
(C6)   Maria increased her involvement in (a) record time (b) church affairs.
(C7)   The priest preached conversion from (a) the pulpit (b) atheism.
(C8)   The radio station publicized vaccinations for the (a) hospital (b) flu.
(C9)   The man expressed his interest in a (a) hurry (b) wallet.
(C10)   The old gentleman heard a tap on (a) Wednesday evening (b) the door.
(C11)   The war increased alienation from the (a) beginning (b) social system.
(C12)   The bill provided some exemptions from the (a) start (b) army.
(C13)   Tommy resisted expulsion from (a) the first (b) high school.
(C14)   The teacher encouraged excitement over (a) the course of the week (b) learning to read.
(C15)   The woman showed her annoyance with (a) a pointed glare (b) the sales pitch.
(C16)   The teenagers began a debate about (a) four in the afternoon (b) access to the gym.

(C16) is excluded from further discussion since in the (a) completion *about* is a degree expression, not a preposition. Applying the argument tests to the remaining items gives the results in Table 4; we see that the authors were fairly successful in constructing NP arguments, but three of their items had instrumental VP completions. Nonetheless, it is clear that an argument preference cannot explain an overall VP advantage for these items.

Table 4
Attachments of Clifton et al. (1991) Sentences

| Item | Completion | | Definiteness |
	VP-attached	NP-attached	
(C1)	argument (inst)	argument	indefinite
(C2)	argument (inst)	argument	indefinite
(C3)	modifier	modifier	indefinite
(C4)	modifier	argument?	definite
(C5)	modifier	argument?	definite
(C6)	modifier	argument?	definite
(C7)	modifier	argument?	indefinite
(C8)	modifier	modifier?	indefinite
(C9)	modifier	argument	definite
(C10)	modifier	modifier	indefinite
(C11)	modifier	argument	indefinite
(C12)	modifier	argument	indefinite
(C13)	modifier	argument	indefinite
(C14)	modifier	argument	indefinite
(C15)	argument (inst)	argument	definite
(C16)	no preposition	modifier?	indefinite

I suggest that there are reasons to doubt that this finding bears on the question of argumenthood in parsing. First, the crucial contrast pairs often differed by more than one word within the PP (unlike most items in the previous two studies). Thus, any differences in reading time between PPs in the two versions of a sentence could be due to these extraneous differences rather than to the different syntactic attachments. Although the dependent measure was average reading time per character, spurious differences between completions could affect average reading speed across the PP. In particular, the extra words that differed were sometimes parts of idioms such as *in record time*, which might well be read quickly simply because they are recognized as units, in contrast to *in church affairs*. Idiomatic phrases could have sped up the VP completion in (C6a), (C9a), (C11a), (C12a) and (C13a), relative to the nonidiomatic (b) completions. In addition, (C14) involved a comparison in the crucial region between *excitement over learning to read* and *excitement over the course of the week*, which differ in syntactic complexity, since the NP-attached completion involves an embedded infinitival clause and two PRO subjects within the PP. Thus, the addi-

tional structure could easily have slowed down the NP completion in (C14b). Another problem with (C13a) is that it is not disambiguated toward VP attachment within the PP: it could have continued ". . . high school he attended," an NP completion. Therefore, an argument preference strategy would not favour the (b) completion here. Two additional items that do not suffer these problems, (C4) and (C5), do contain a definite direct object and could have disfavoured the NP attachment for that reason. Thus, among the nine items that do contrast an NP argument with a VP modifier, only (C7) lacks an independent reason why the (a) completion might be faster.[48]

What about the six remaining relevant items that did not involve an argumenthood contrast? One of these contained a definite direct object (C15). This and another two items, (C1) and (C10), involved a definite NP within the PP in the (b) completion but not in the (a) completion; although this does not affect the preferred attachment site, it could take additional time for the processor to search for a referent for the definite NP. In summary, an overall advantage for the VP completions in reading time for the PP in this experiment is consistent with the argument preference hypothesis, because there are plausible confounds that could neutralize it in the examples where it would have applied and plausible reasons to expect a VP preference in most items where it would not have applied.

4.4   Summary

The clear conclusion from this section is that all of the experiments under examination here confounded numerous factors in assessing attachment preferences, and none of them constitute clear evidence against the operation of an argument preference. While the experiment by Clifton et al. also fails to provide any evidence *for* such a principle, the findings of the other two experiments, taken together, make a strong case for the need for it. Specifically, Minimal Attachment and other purely structural preferences cannot explain why Taraban and McClelland's materials showed an NP preference while Rayner et al.'s showed a VP preference; definiteness also cannot account for this contrast. I have shown that the two sets of materials do differ substantially in their argument properties. Those showing the VP preference mostly contrast VP arguments with NP modifiers (including the VP bias items in Taraban and McClelland's experiment 2), while those showing the NP preference compared NP arguments with VP modifiers or else modifiers on both sites. Thus, across these two experiments a large amount of the variance in attachment preferences is explained by argumenthood. In experiments currently underway in collaboration with Ted Gibson, we are testing for this preference directly, using a paradigm similar to that of Clifton et al. with items that differ on only one word and that contain indefinite direct objects (following the logic of Spivey-Knowlton and Sedivy 1995). For a brief description of the experimental design, see Schütze 1995.

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[48] In fact, (C7) contains a transitive use of the verb *preach* that leaves both completions sounding very odd; to the extent that the object was difficult to process, this could slow the PP down more in the (b) completion, which requires attachment to that object.

5.   Conclusions

In this paper I have shown that several important experimental studies that claimed to address the question of whether there is a purely structural preference in initial PP attachments to VPs versus NPs were crucially flawed. I have surveyed a number of objective syntactic tests for determining when a PP stands in an argument relation to a noun or verb head, so that the materials in these and subsequent experiments can be assessed for the role that this factor plays in parsing. I have argued that the experiments reviewed could all be consistent with Abney's argument preference hypothesis and have suggested a more adequate way to test that hypothesis. In closing, I would like to spell out in more detail how this hypothesis might fit into a more comprehensive theory of parsing as applied to V-NP-PP ambiguities.

The basic underlying claim is that argumenthood is a syntactico-semantic property of linguistic expressions that cannot be reduced to co-occurrence frequencies between the relevant heads, although it surely correlates with such frequencies to a substantial degree. To claim that the parser embodies an argument preference strategy is to claim that the argument/modifier contrast explains some amount of the variance in attachment preferences that cannot be explained by other factors, including frequency. Our hope is to be able to demonstrate this both by post hoc analysis of the experiment just mentioned above and by an experiment where these two factors are placed in direct competition, using items with a less frequent argument completion and a more frequent modifier completion. Even if these experiments are successful, however, they will not show that factors other than argumenthood are unnecessary. It seems to us that they clearly are. Our claim would simply be that an argument-based strategy is *also* necessary.

If this view is correct, then the most straightforward way of exploring what *other* factors are at play is to look at cases where the NP- and VP-attachments of the PP are of the same thematic type: either both arguments, as in (133), or both modifiers, as in (134).

(133) a.   The President suggested a solution to the senator/crisis.
       b.   The manager notified the president of the decision/corporation.

(134) a.   The thieves stole all the paintings in the afternoon/museum.
       b.   The document described the group's activities in code/Alabama.

Since an argument preference strategy makes no decision in such cases, we expect them to show the effects of other factors. These might include (at least) pure structural effects such as a Recency/Late Closure preference, which would favour NP-attachment, and Predicate Proximity (Gibson et al. in press; cf. Abney 1989), which would favour VP-attachment; relative frequencies of the different possible theta-grids of the heads in question (cf. MacDonald, Pearlmutter & Seidenberg 1994, in press); referential factors (Altmann & Steedman 1988); real-world plausibility (Taraban & McClelland 1988, 1990); etc. Such factors would of course also be at work when there *is* an argumenthood contrast, each con-

tributing to the parser's overall preference and potentially obscuring an argument preference (e.g., in Altmann and Steedman's experiment, which involved instrumental VP-attachments contrasting with NP-modifier attachments but found an overall NP-preference, presumably attributable to the context sentences they used).

If it turns out that noun argument completions are processed faster than verb modifier completions in V-NP-PP sentences when these other factors are controlled for, it would give strong support to the claim that argument attachments are favoured over modifier attachments in general, and that the human parser immediately makes use of information about possible argument combinations of N, V, and P heads. It would be most significant if this preference appears at the disambiguating word itself, and thus is not a later semantic effect. Such a finding would contradict the claims of Minimal Attachment, and any other theory that initially prefers verb attachments to noun attachments across the board in V-NP-PP ambiguities, and it would also refute Taraban and McClelland's claim that no general grammatical principle whatsoever is at work. It would be consistent with the general theory of ambiguity resolution proposed by Gibson (1991), which uses a preference for maximizing theta-assignments on-line to explain many other parsing effects. This general line of research is driven by the hypothesis that properties of grammar matter on-line to the parser, because these two cognitive systems are very closely related.

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