A Neurophysiological Investigation of *Wh*-Islands
Author(s): Robert Kluender
Proceedings of the Sixteenth Annual Meeting of the Berkeley Linguistics Society (1990), pp. 187-203

A Neurophysiological Investigation of *Wh*-Islands*

Robert Kluender
University of California, San Diego

1. Introduction

There is a growing body of evidence for the role of lexical semantic factors in what have heretofore been considered purely syntactic processes. Centineo (1986), Van Valin (1987, to appear), Zaenen (1988, 1989), and McClure (1990) have pointed out the role of aspectual verb classes (*Aktionsarten*) in characterizing the class of unaccusative verbs crosslinguistically; Pinker (1989) has proposed a lexical semantic account of the verb classes that participate in various argument structure-changing rules in English (passive, dative shift, locative alternation, and causativization). In this paper I argue that taking a similar approach to the analysis of unbounded dependencies in English provides insight into many poorly understood features of these constructions.

Generative linguistics has traditionally provided structural explanations for processes of extraction in general, and at least since Ross's (1967) original proposals, for island constraints in particular. In Chomsky's (1986a) barriers framework (cf. also Frampton 1990), the standard island constraints are handled by a version of subjacency which equates severity of violation in extraction of arguments with the number of syntactic barriers crossed: 'Our intuitive idea is that movement should become "worse" as more barriers are crossed, the best case being the crossing of zero barriers.' (Chomsky 1986a:28)

At the same time, various researchers over the years have pointed out the role of non-structural factors in processes of extraction. The notion of 'semantic dominance' was first introduced by Erteschik Shir in her dissertation (1977), and further developed in Erteschik Shir and Lappin (1979) and Erteschik Shir (1981); the definition is given in (1).

(1) A constituent *c* of a sentence *S* is dominant in *S* if and only if the speaker intends to direct the hearer's attention to the intension of *c*, by uttering *S*. (Erteschik Shir and Lappin 1979, Erteschik Shir 1981)

Here the intension of a constituent can be intuitively thought of as its semantic content. The hypothesis that results from this is given in (2).

(2) An NP can only be extracted out of clauses which may be interpreted as dominant or out of phrases in which the NP may itself be regarded as dominant. (Erteschik Shir and Lappin 1979)

Additional insight into non-structural factors affecting extraction was provided by Kuno (1976), who originally introduced a thematic constraint on relativization which simply stated that a relative clause must be a statement about its head noun. This idea is expanded upon in Kuno (1987), which provides a more general constraint on extraction, the Topichood Condition.

(3) Only those constituents in a sentence that qualify as the topic of the sentence can undergo extraction processes (i.e. *Wh-Q* Movement, *Wh*-Relative Movement, Topicalization, and *It*-Clefting). (Kuno 1987)

This condition not only bears a certain resemblance to the second half of the disjunction in (2), but is also reminiscent of the first condition of Keenan's (1974) Functional Principle.

(4) (i) The reference of the argument expression must be determinable *independently* of the meaning or reference of the function symbol.

(ii) Functions which apply to the argument however may vary with the choice of argument (and so need not be independent of it). (Keenan 1974)

Finally, Ross (1987) has proposed a general account of syntactic prototypes which is at least in spirit not all that different from the barriers proposals.

> 'The idea here is that it is possible for a sentence to deviate from a prototype, and yet not manifest any drop in acceptability. Losses in viability are cumulative, and only when there have been enough of them for a certain threshold value to be exceeded will the speakers of the language perceive that the sentence is less than perfect.' (Ross 1987:310)

This paper is an attempt to look for correlates of these notions in the processing of extraction structures. It suggests that the effects of subjacency, dominance, topichood, function-argument structure, and prototypicality or viability can to a large extent be subsumed under the notion of 'semantic barrier'. Specifically, the following claims are made.

(5) (a) Open-class, low-frequency, referentially specific constituents are the best candidates for extraction but simultaneously difficult to extract over ('semantic barriers').

(b) Conversely, closed-class, high-frequency, referentially non-specific constituents are relatively easy to extract over.

(c) Severity of violation in processes of extraction can at least in part be equated with the number of semantic barriers crossed.

(d) The subtle effects of semantic barriers should be reflected in any direct measure of processing load.

The structure of the paper is as follows. After some preliminary discussion, in section 2 I provide evidence for claims (5a) and (5b) in the form of known exceptions to the complex noun phrase, *wh*-island, and coordinate structure constraints in English. The cumulative effects of semantic barriers (5c) are shown in section 3. Finally, in section 4 I propose an experimental means of validating the hypotheses proposed in this paper (5d).

2. The Nature of Semantic Barriers

The notion of semantic barrierhood is intimately tied to the structure of the lexicon and the referential properties of individual lexical items. Psycholinguists traditionally distinguish between two broad lexical classes, namely 'open-class' or 'content' words (nouns, verbs, adjectives, and derived adverbs), and 'closed-class' or 'function' words (articles, conjunctions, prepositions, and pronouns). However,

there is evidence that this categorical distinction has been superimposed on an underlying continuum.

Gentner (1981) has shown for example that in terms of frequency distribution, the pattern exhibited by verbs is intermediate between that of nouns and function words. Nouns are most heavily represented in the low frequency ranges, in classic open-class fashion. Function words are almost exclusively represented in the highest frequency range, the classic closed-class pattern. Verbs are more evenly distributed across all frequency ranges; although they are also represented in the lower frequency ranges, unlike function words, their numbers taper off at these lower frequencies, unlike nouns.

Gradations of class membership exist within lexical categories as well. Prepositions are known to appear in speech errors characteristic of both open-class and closed-class items. Further, Friederici (1985) has shown in a study of the effects of context on word monitoring that prepositions behave more like open-class items when used referentially, i.e. when selected for their meaning, and more like closed-class items when selected merely as part of a verb's subcategorization frame.

Returning to the notion of semantic barrier, the way the preceding facts about the lexicon relate to questions of extraction is as follows: gradations of acceptability in unbounded dependencies often reflect gradations of class membership and referentiality in the constituents of these structures (the extracted element itself, the matrix subject, the matrix predicate, the head noun in a complex noun phrase, the embedded *wh*-phrase or complementizer in an embedded question, and the embedded subject and predicate). Constituents nearer the open-class, low-frequency, referentially specific end of the open- and closed-class continuum (which I will henceforth refer to merely as 'open-class' elements) are optimal candidates for extraction because they are maximally salient. Such elements satisfy the first condition of Keenan's (1974) Functional Principle, which requires the reference of argument expressions to be readily identifiable independent of what follows in the function symbol.

On the other hand, the salience of these same open-class elements makes them semantic barriers when they occur within the function symbol; as Keenan (1974) points out in reference to restrictive relative clauses, in such cases there is more than one independent reference to be made. This has the following effects on the processing of such structures. First, in Kuno's (1976, 1987) terms, it makes it more difficult to determine what the sentence is about, and what should qualify as its topic. Second, it makes filler-gap assignment (Fodor 1978) more difficult by placing greater demands on short-term memory.

Conversely, closed-class, high-frequency, referentially non-specific constituents (henceforth simply 'closed-class' elements) occurring within the function symbol do not produce these effects by virtue of the fact that no independent reference is invoked. Rather, in fulfillment of the second condition of the Functional Principle, they keep the function symbol referentially dependent on, or semantically subordinate to, the argument expression.

If Ross (1987) is correct, then the effects of semantic barriers may not be consciously perceived until enough of them have accumulated in any one structure to collectively draw attention to themselves. As I will show in section 3, this is

generally the case in standard island violations: they contain a number of semantic barriers. On the other hand, exceptions to the various island constraints noted (or more often footnoted) in the generative literature are usually void of semantic barriers. Representative examples are presented in this section, arranged according to the constituent where a barrier can appear. However, crucial distinctions have often been masked in the existing literature by the use of divergent lexical content across examples or by the inclusion of more than one semantic barrier within examples. To avoid these problems, the examples in this section have been set up as minimal pairs wherever possible: paired sentences contrast in one barrier only. As a result, the contrasts are often pretty slim, but only those examples have been included where most people are able to get the relevant contrasts. Since the distinctions are often not even a question mark away from each other, however, I have provided relative markers as guides: the equals sign indicates 'seems about as good as', and the greater-than sign indicates 'seems better than'. Where there is no marker, it is not clear if a contrast exists, though some people get one. Hopefully, when the experimental data are all in it will be possible to talk about these distinctions with greater precision.

2.1. Argument Expressions

Much has been written in recent years about the role of referentiality in processes of *wh*-movement (cf. Pesetsky 1987, Rizzi 1989, and Cinque 1989 & 1990). In particular, it has been demonstrated that the more referentially specific an NP, the better it is as a candidate for extraction. This is shown in (6), taken from Maling and Zaenen (1982:287, fn. 3), based on a similar observation about Italian in Rizzi (1982:70, fn. 5).

(6) (a) *Which article* don't you remember who wrote? >
(b) *What* don't you remember who wrote? (Maling and Zaenen 1982)

Pesetsky (1987) points out that *which*-N' phrases are more restricted in their set of possible referents than *who, what,* or *how many*-N' phrases (cf. also Rizzi 1989 and Cinque 1989, 1990).

There is a tacit appeal in these accounts to a continuum of referentiality that I would like to make explicit here. Virtually all the island constraint exceptions cited in the literature involve the topicalization, relativization, or clefting of a fully referential NP. When this NP is made increasingly less specific in reference, the following contrasts in extractability emerge.

(7) (a) This is *a paper* that you really need to find someone you can intimidate with. > (adopted from Chung and McCloskey 1983)
(b) *Which paper* do you really need to find someone you can intimidate with? >
(c) *How many papers* do you really need to find someone you can intimidate with? >
(d) *What* do you really need to find someone you can intimidate with?

(8) (a) It's *the Marine Corps* that I know the officers in. (Bolinger 1972) >
(b) *Which service branch* do you know the officers in? >
(c) *How many service branches* do you know the officers in? >
(d) *What* do you know the officers in?

(9) (a) *...the ponderous formal agreements* that I doubted any Syrian government would be able to sign with the United States and survive. (Goldsmith 1985)
(b) *Which ponderous formal agreements* did you doubt any Syrian government would be able to sign with the United States and survive? >
(c) *How many ponderous formal agreements* did you doubt any Syrian government would be able to sign with the United States and survive? >
(d) *What* did you doubt any Syrian government would be able to sign with the United States and survive?

(7a) shows relativization out of a relative clause, (8a) clefting out of an NP with a PP complement, and (9a) relativization out of a coordinate structure. When the referential NP is converted to a *which*-N' phrase in (7b), (8b), and (9b), there is a slight deterioration as the set of possible referents is increased. The extraction of a quantified *wh*-phrase in (7c), (8c), and (9c) is somewhat less felicitous, while *what*-substitution in (7d), (8d), and (9d) results in a standard violation. It seems clear that the referential determinability of the argument expression (the first condition of the Functional Principle) plays a crucial role in these examples.[1] The (d) examples show clear frequency and lexical class effects as well: the closed-class interrogative pronoun *what* is much higher in frequency than the corresponding open-class noun phrases.

2.2. Head Nouns in Complex Noun Phrases

In contrast, referential specificity of head nouns impedes extraction out of complex NPs. These well-known facts (as they pertain to picture NPs) are given in (10), and were originally discussed in Chomsky (1973:239, fn. 19).

(10) (a) Who did you see pictures of? >
(b) Who did you see *a* picture of? >
(c) Who did you see *the* picture of? >
(d) Who did you see *his* picture of? >
(e) Who did you see *John's* picture of? (Erteschik Shir and Lappin 1979)

Note that there is an increase both in referential specificity and in degree of open-class membership from (10a) through (10e). (11) shows the same contrast in extraction out of a relative clause.[2]

(11) (a) This is the paper that we really need to find *someone* who understands. > (Chung and McCloskey 1983)
(b) This is the paper that we really need to find *the guy* who understands. >
(c) This is the paper that we really need to find *the linguist* who understands.

Two further observations are in order here. First, virtually all grammatical or marginal extractions out of relative clauses in the literature involve quantified head nouns, which are non-specific in reference. Note also that indefinite pronoun heads such as that in (11a) are closed-class elements. Second, the introduction of a referentially specific head noun in the intermediate clause in (11b) necessitates the

mental identification of an extra referent, thereby increasing the processing load. In Kuno's (1976, 1987) terms, it becomes more difficult to interpret the first head noun as the topic of the sentence. In (11b), it's unclear if the sentence is about *the paper* or *the guy*. This conflict is exacerbated when the head noun is made not only referentially specific but of a lower frequency as well, as shown in (11c).[3]

In sections 2.1. and 2.2. we have seen the following reciprocal relationship: the more referentially specific the argument expression, the better the extraction, and the more referentially specific the head noun of a complex NP out of which extraction occurs, the worse the extraction. This is precisely as predicted by claims (5a) and (5b). In subsequent sections we will explore further cases of this tradeoff between the referentiality of argument expressions and that of expressions figuring in the function symbol.

2.3. Complementizers and Embedded *Wh*-Phrases in *Wh*-Islands

Next we turn to the complementizers and embedded *wh*-specifier phrases of *wh*-islands. In this case we are dealing almost exclusively with what are traditionally considered closed-class elements, yet there are contrasts in the extent to which these elements will license extraction as well. These contrasts are summarized in (12). A general hierarchy of accessibility for extraction out of *wh*-islands is shown on the left; Engdahl's (1983) hierarchy of accessibility for parasitic gap formation is given alongside on the right for comparison.

(12) Accessibility of:

Wh-Islands		Parasitic Gaps		
that	>	manner adverbs	>	(untensed
if	>	temporal adverbs	>	domains) >
whether	>	purpose clauses	>	
how	>			
when		*that/than* clauses	>	(tensed
where	>	*when/because/if* clauses	>	domains)
why	>			
what/who	>	relative clauses and indirect questions		

(Engdahl 1983)

Note that these hierarchies evolved independently of each other. Abstracting away from the difference in finiteness of the embedded clause, which we will return to in section 2.5., there are striking similarities between the two: the ordering of *that* and *if* complementizers, of manner and temporal adverbials, of these two relative to clauses of purpose and causation, and of all of these relative to clauses introduced by *wh*-arguments. I claim that these gradations are due to varying degrees of open-class membership based on referentiality and frequency; those elements which are more referential in character and of a lower frequency are harder to extract over than those with less potential to refer and of a higher frequency.

Turning to the *wh*-island hierarchy on the left, we see a clear increase in degree of open-class membership from top to bottom. Extractions out of *wh*-islands introduced by complementizers are generally pretty good, if not fully acceptable.

These are shown in (13) and (14).

(13) Which medal did Bob doubt (a) *that* she would win? >
(b) *if* she would win? >
(c) *whether* she would win?

(14) Which medal did Bob wonder (a) *if* she would win? >
(b) *whether* she would win?

Many speakers get the contrasts between the various complementizers in the order given; some don't. However the complementizer *that* is generally assumed to be semantically void of content to the point of being deletable. This is not true of the complementizers *if* and *whether*: *if* refers to a possible state of affairs from among an infinite set of such possible states, while *whether* both historically and synchronically refers to one of only two possible (alternative) states of affairs, and can thus be said to be more referentially specific in character. In addition, there is a marked difference in frequency between the two: *if* has a mean frequency of 2199 in the Francis and Kučera (1982) frequency list for English while *whether* has a mean frequency of only 286.

The adverbials *how, when, where,* and *why* are more referential in character than complementizers, and hence harder to extract over. Example (15) shows minimal contrasts between the complementizer *whether* and the manner adverbial *how.*

(15) (a) Which opera singer did you wonder *whether* Mary could stand?
> *how*
(b) Which books did he tell the students *whether* they should read?
> *how*

Among the adverbials themselves, the manner adverbial *how* is generally amenable to extraction, the temporal locatives *when* and *where* less so. This is shown in (16), (17), and (18).

(16) (a) What do you know *how* to fix? =
(b) Who can you remember *how* to imitate? =
(c) What did you figure out *how* to finance? (Culicover and Wilkins 1984) >

(17) (a) Who did you figure out *when* to visit? =
(b) What did you forget *when* to deliver?

(18) (a) Who did you forget *where* to seat? =
(b) What did you figure out *where* to park?

I have no ready explanation for this difference. However, the contrast in (19) between *when* and *why* is again most likely due to a difference in frequency: a mean frequency of 2333 for *when* versus a mean frequency of 404 for *why.*

(19) Which book did he tell the class (a) *when* they were going to read? >
(b) *why* they were going to read?

(20) and (21) contrast *wh*-adverbials with a *wh*-argument.

(20) (a) Who did he wonder *when* to give it to? >
(b) Who did he wonder *what* to give to?

(21) (a) Who did he wonder *why* he should give anything to? >
(b) Who did he wonder *what* he should give to?

I claim that this is a difference of class membership and referentiality as well. Interrogative pronouns refer to entities encoded by nominal expressions (i.e. to densely constituted, perceptually or conceptually bounded entities) while *wh*-adverbials refer to the relations predicated of such salient, bounded entities in time and space (cf. Gentner 1981, Langacker 1987). Thus in comparison to interrogative pronouns, *wh*-adverbials exhibit the same intermediate status of class membership that verbs have in comparison to nouns.

To sum up, in this section we have seen how gradations of extractability over the complementizers and *wh*-specifiers of *wh*-islands reflect differences of referentiality and frequency in closed-class elements. These facts closely parallel the contrasts we saw in extractability over the head nouns of complex NPs in the previous section, as well as the contrasts in accessibility of various clause types to parasitic gap formation shown in (12). In the next section we will see similar contrasts in extractability over matrix subjects.

2.4. Embedding Subject

This section shows the curious fact that almost all cases of felicitous extraction out of relative clauses in the literature -- and not just in English -- involve first and second person subjects in the clause immediately superordinate to the relative clause (what I am referring to as the 'embedding' clause). Having a third person subject, as in (22b & c), makes the extraction somewhat worse.

(22) (a) That's one trick that *I've* known a lot of people who've been taken in by. > (Chung and McCloskey 1983)
(b) That's one trick that *he's* known a lot of people who've been taken in by. >
(c) That's one trick that *the attorney's* known a lot of people who've been taken in by.

The crucial factor here appears to be relative cognitive distance from the speech event, sometimes referred to as an empathy hierarchy. The reference of first and second person indexical pronouns is contextually determined and implicitly given, while third person anaphorics are usually dependent for their reference on their referential antecedents. Referential NPs are of course maximally explicit in reference. So there are once again degrees of referential specificity involved in these examples; there is also a clear shift from a closed-class to an open-class subject in (22c). As in the case of referentially specific head nouns (section 2.2.), each independent referential link that needs to be established in the function symbol complicates the processing of the functional expression as a whole.

2.5. Embedded Subject and Predicate

This section demonstrates the well-known fact that it is easier to extract out of *wh*-islands (23) and relative clauses (24) (and also to form parasitic gaps, as indicated in (12) above) when the embedded clause is non-finite and lacks an overt subject.

(23) He told me about a book which I can't figure out...

(a)	whether *to buy* or not.	>	(b)	whether *I should buy* or not.
	how *to read.*	>		how *I should read.*
	where *to obtain.*	>		where *I should obtain.*
	what *to do* about.	>		what *I should do* about.
				(Ross 1967)

(24) (a) This is a paper that we really need to find someone *to intimidate* with. >
(b) This is a paper that we really need to find someone *we can intimidate* with.

It is obvious that a specified subject is more referentially specific than an unspecified one, and hence harder to extract over. The reason is that once again an additional independent reference is required in the function symbol.

Although in the above examples it is impossible to dissociate finite morphology on the verb from the presence of an overt subject, (25) demonstrates that finiteness alone can act as a semantic barrier itself.

(25) (a) That's the kid that I found a book *for you to read* out loud to. >
(b) That's the kid that I found a book *(that) you can read* out loud to.

Finite verb forms (which in English require overt subjects) are referentially more specific than non-finite forms insofar as finiteness relates the time of events referred to in the discourse to the time of the speech event itself. For this reason tense is often considered an indexical expression. This is reflected in the increased morphological complexity of finite verb forms, and in this sense they can be considered semantic barriers in their own right.

2.6. Embedding Predicate

Much attention has been paid over the years to the role of the matrix predicate in processes of extraction. In this section I show that viewing these cases in light of the distinctions presented above, namely in terms of where the embedding predicate falls on the open- vs. closed-class, frequency and referentiality continuum, can help make some sense of why particular verb classes should be more opaque to extraction than others. In addition, I refer to three relevant lines of current research: the study of complex predicates or 'light' verbs (Cattell 1984, Grimshaw and Mester 1988, Kearns 1988, Sells 1989, Dubinsky 1989, Pelletier 1990, Di Sciullo and Rosen 1990), of argument structure-changing rules (Pinker 1989), and of unaccusative verbs (Centineo 1986, Van Valin 1987 & to appear, Zaenen 1988 & 1989, McClure 1990).

Light verbs are typically non-specific in reference, picking up their reference from their NP complements instead. The most common light verbs in English are the high frequency verbs *do, have, give, make,* and *take.* Pinker (1989) points out that these verbs act as little more than slot-fillers or tense-carriers in English, and that the role they perform is often filled by affixes in other languages; several of the researchers listed above have suggested that these verbs have unspecified or only partially specified argument structures. These facts taken together lead to the conclusion that these verbs have a status closer to that of function words, which predicts that they should be easier to extract over than other types of verbs, in

accordance with claim (5b).

Pinker (1989) points out that notions of 'manner' turn up consistently in the definition of verb classes subject to argument-structure changing rules, as do notions of accomplishment, creation, and coming into existence. These latter notions figure prominently in lexical semantic accounts of unaccusativity as well. The four-way classification of verbs into stative, activity, achievement, and accomplishment verbs proposed in Vendler (1967) and refined in Dowty (1979) has been used with great success to characterize the class of unaccusative verbs in Italian, Dutch, Japanese, and English. In every analysis presented so far (see references above) the set of unaccusative verbs has been derived from the non-activity verb classes, namely stative, achievement, and accomplishment verbs; activity verbs never form part of this set.

Van Valin (to appear) points out that what the non-activity verbs have in common is a state predicate in their logical structure. What I will claim here is that verbs built up from state predicates are by nature less referential than verbs with activity predicates. This predicts that, all other things being equal, it should be easier to extract over non-activity verbs than activity verbs.

With this battery of interrelated facts, the behavior of embedding predicates in unbounded dependencies can be seen to be very systematic. First let us look at verbs which take sentential complements. Factive verbs are generally stative or achievement verbs, and thus extraction over such predicates is for the most part unimpaired as predicted. But within the class of factive verbs there are frequency effects: while extractions over high-frequency factives like *know* and *forget* are unproblematic, extractions over low-frequency emotive factives like *rejoice, exult,* and *grieve* are consistently bad.

Manner-of-speaking verbs are invariably activity verbs, which makes them as a class more difficult to extract over. But within the manner-of-speaking verbs there are also frequency effects. Erteschik Shir (1977) divided manner-of-speaking verbs into two groups based on the judgements of acceptability she got for extraction over such predicates. These are given in (26).

(26) *Questionable*: exclaim, grunt, holler, mumble, murmur, mutter, roar, scream, shout, sigh, snort, stammer, wail, whine

Bad: animadvert, coo, croak, dictate, editorialize, eulogize, jeer, lisp, purr, quip, rumble, simper, snarl, transcribe, ululate (Erteschik Shir 1977)

Checking these two groups against the Francis and Kučera (1982) frequency list for English reveals a mean frequency of 21 for the 'questionable' group and a mean frequency of 3 for the 'bad' group.

Bridge verbs are typically stative, in line with the prediction that verbs with state predicates should be easier to extract over. They are also all very high in frequency. Furthermore, compared to the manner-of-speaking verbs, bridge verbs have little referential content. This is demonstrated in (27), where the contrast is brought into relief by the relative lack of referentiality in the extracted element as well.

(27) (a) How angry did Mary *say* that John was? >
(b) How angry did Mary *say softly* that John was? =
(c) How angry did Mary *whisper* that John was? (Culicover and Wilkins 1984)

When the embedding bridge verb in (27a) is made more explicitly referential through the addition of a manner adverbial in (27b), it behaves much like the manner-of-speaking verb in (27c) in impeding extraction.[4]

The increased referentiality of the manner-of-speaking verbs implied by their very name is something that I am claiming is true of all activity verbs. The relative lack of referential content of the bridge verbs, on the other hand, is something that I am claiming is true of stative predicates in general. Bridge verbs contribute nothing substantial to the meaning of the sentence other than to signal the introduction of the proposition to which the hearer's attention is directed. This is what makes sentential complements of bridge verbs 'semantically dominant' in Erteschik Shir's terms. In a way the bridge verbs have become little more than slot-fillers or tense-carriers themselves. In fact, the bridge verbs can be said to behave much like the light verbs, whose sole function seems to be the introduction of their semantically dominant NP complements.

Turning now to verbs which take complex NP complements, we can see that frequency does not play much of a role in complex predicates because light verbs are virtually non-referential in the first place and thus easy to extract over. This is true even when low-frequency variants appear in the verbal position, as in (28b).

(28) (a) What did she *make* a complaint that he had done? =
(b) What did she *lodge/register/voice* a complaint that he had done? >
(c) What did she *investigate* a complaint that he had done?

Note further that complex predicates are typically statives with verbs of possession in the verbal position (*have a feeling, hold a belief, entertain hopes*) or accomplishments with verbs of creation in the verbal position (*make a claim, lodge a complaint, advance a hypothesis, put forth an idea, start a rumor*). When the verbal position is filled with an activity verb, as in (28c), extraction is impeded.

Analogous facts pertain in extractions out of picture noun phrases. When the embedding predicate is a stative (*have*), achievement (*see, find*), or accomplishment (*draw, develop*) verb, as in (29a), the extraction is fine. When it is an activity verb (*analyze, criticize, discuss*), as in (29b), the extraction deteriorates. Interestingly, this deterioration also occurs with achievement (*lose*) and accomplishment (*destroy*) verbs that are not verbs of creation or coming into existence.

(29)

What did John	*(a)*	have see find draw develop	>	*(b)* analyze criticize discuss lose destroy	a picture of?

Similarly, the best embedding predicates in exceptions to the relative clause subcase of the CNPC are stative verbs like *be, have,* and *know,* and cognitive

achievement verbs like *see, hear, notice, recognize, find* and *meet.* Virtually all the exceptions to the CNPC cited in the literature are constructed from verbs of these types. When they are replaced by activity verbs, the extractions suffer. This progressive deterioration is shown in (30).

(30) (a) This is a paper that *there* really *must be* someone who understands. >
(b) This is a paper that we really need to *find* someone who understands. >
(c) This is a paper that we really need to *talk to* someone who understands. >
(d) This is a paper that we really need to *emulate* anyone who understands.

(30c) and (30d) both contain activity verbs; note the additional effect of lower frequency in (30d).

In summary, we have seen once again how factors of frequency, referential specificity, and lexical class membership affect the acceptability of extraction -- this time as manifested in the embedding predicate. In addition, we have seen that the two predictions made earlier in this section have been borne out. First, even low-frequency light verbs seem to pose no barrier to extraction due to their status as function words. Second, activity verbs are consistently more difficult to extract over than non-activity verbs, which we suggested is due to the fact that activity verbs are by nature more referentially specific. Finally, the impeding effect of referential specificity in the embedding predicate falls out from the Functional Principle: a referentially specific predicate within the function symbol requires the establishment of an independent reference on the part of the hearer in addition to that of the argument expression, with a correspondingly higher processing cost.

3. Cumulative Effects of Semantic Barriers

On the basis of the discussion in section 2, we are now ready to turn to the third claim (5c) made at the beginning of this paper: the more semantic barriers crossed in an extraction, the worse it becomes. It was pointed out earlier that the effects of semantic barriers may not be consciously perceived until there are enough of them in any given structure to interfere significantly with processing; hence the potential difficulty of perceiving the contrasts in the previous section. However in the following example it is possible to witness the progressive breakdown of a relatively acceptable extraction out of a relative clause as the closed-class constituents of the sentence are successively replaced with constituents exhibiting more open-class characteristics.

(31) (a) This is a paper that we really need to find someone to intimidate with. >
(b) This is a paper that we really need to find someone *we can intimidate* with. >
(c) This is a paper that we really need to find someone *that we can intimidate* with. >
(d) This is a paper that we really need to find someone *who we can intimidate* with. >
(e) This is the paper that we really need to find *the linguist who we intimidated* with. >

(f) This is the paper that we really need to *razz the linguist who we intimidated* with. >

(g) This is the paper that *the audience* really need to *razz the linguist who we intimidated* with. >

(h) This is the paper *which the audience* really need to *razz the linguist who we intimidated* with.

In (31b) finite morphology and an overt subject appear in the embedded clause; in (31c) an overt complementizer appears; in (31d) a *wh*-relative pronoun replaces the complementizer; in (31e) the head noun becomes referentially specific, and in (31f) the embedding predicate becomes a low-frequency activity verb. In (31g) the matrix subject switches from a first person indexical to a referentially specific NP, and in (31h) the complementizer is again replaced with a *wh*-relative pronoun.

In (32a) the initial argument expression is made less referentially specific by changing the extraction type from relativization to question formation with a *which*-N' phrase, and in (32b) the extracted element is made even less referentially specific (and more closed-class in nature) by converting it to an interrogative pronoun.

(32) (a) *Which paper* do the audience really need to razz the linguist who we intimidated with? >

(b) *What* do the audience really need to razz the linguist who we intimidated with?

The result is relatively uninterpretable compared to what we started out with in (31a), and looks for all intents and purposes like a 'core case' island violation. Note further the extent to which the argument expression in (32b) depends for its reference on that of the function symbol, making the functional expression as a whole unacceptable (Keenan 1974). It is true that we started out with a (perhaps for some marginal) exception to the CNPC, but the same effect can be demonstrated on a perfectly grammatical, garden-variety long-distance extraction. Limitations of space prevent me from doing so here, and so I will leave this as an exercise for the ambitious reader.

4. Experimental Validation of Semantic Barriers

In closing I would like to discuss briefly the experimental research I am currently engaged in to test the fourth claim (5d) made above, namely that the effects of semantic barriers should be reflected in any direct measure of processing load. The specific predictions that this claim gives rise to are the following. First, extracted open-class words (i.e. topicalized, relativized or clefted NPs and *which*-N' constructions) should require more processing than extracted closed-class words (*who* or *what*). Second, open-class elements intervening between filler and gap should require more processing than closed-class elements. Finally, the increased processing load of open-class elements should be detectable even when they occur in otherwise perfectly grammatical constructions, with or without long extraction.

There are three versions of the current experiment, each designed to elicit a different response to unbounded dependencies: reaction time, scalar judgements of acceptability, and evoked response brain potentials. It is this latter measure which I will focus on here. Evoked response potentials, or ERPs, are computer-averaged

waveforms of the EEG synchronized in response to cognitive events and recorded at various electrode sites on the human scalp. Over the past fifteen years various components of this averaged waveform have been shown to be sensitive to different cognitive factors: attention, predictability, anticipation, etc. In a series of studies, Kutas and Hillyard (1980a, 1980b, 1983) showed that the inclusion of semantic anomalies in otherwise semantically and syntactically well-formed sentences of English (e.g. 'A low often brings *kittens* or snow') presented to subjects one word at a time consistently elicit ERPs with a negative wave component peaking at 400 msec. (the 'N400') after the appearance of the incongruous word. This is a very robust effect and is clearly distinguishable from the typical response to other unexpected or surprising task-relevant stimuli (such as showing the target word in a larger type size), namely a positive wave component peaking around 300 msec. (the 'P300') poststimulus.

Significantly, N400 effects have also been observed in a number of studies involving the manipulation of class membership and frequency. The following facts are known about the N400 in relation to these two factors.

(33) (a) The amplitude of the N400 elicited by content words is larger than the N400 response to function words.
(b) The amplitude of the N400 response to content words decreases monotonically as sentences progress.
(c) This decrease in amplitude reflects the influence of semantic but not syntactic context.
(d) Low-frequency content words elicit a larger N400 than high-frequency content words when semantic context is weak or absent. (Van Petten and Kutas, to appear)

These facts suggest that the N400 is an appropriate measure for investigating the role of lexical semantic factors in unbounded dependencies and testing the set of predictions stated at the beginning of this section. The first set of experiments is designed to study the effects of various complementizers and *wh*-phrases on extraction out of *wh*-islands (see section 2.3.). Later I will be looking at specificity effects in the *wh*-specifiers of *wh*-islands and the head nouns of complex noun phrases, as well as at the effects of subject and verb choice in the superordinate clause on extraction out of an embedding.

In conclusion, the facts illustrated in this paper show that degrees of referentiality, frequency, and lexical class membership have similar and related effects across all the major constituents of an unbounded dependency, and that these factors collectively play a major role in determining the acceptability of extraction. These findings support the idea that the examination of syntactic phenomena in light of lexical semantic theories is a profitable research strategy. In particular, the unexpected role of aspectual verb classes in syntactic phenomena as seemingly unrelated as unaccusativity and unbounded dependencies, and of other semantically determined sub-classes of verbs in argument structure-changing rules and processes of extraction, suggests that these same factors may well be found lurking around other areas of syntax as well. The approach to the study of unbounded dependencies taken in this paper also has certain affinities with formal semantic, pragmatic, and syntactic theories of extraction which treat such structures as instances of predication. This is an idea which I am pursuing in concurrent work (Kluender, in

preparation). The strong advantage of this approach is that the claims it makes are amenable to experimental validation in the on-line processing of natural language. As such it presents a unique opportunity to subject the findings of linguistic theory to the scrutiny of cognitive neuroscience.

Footnotes

*This research was supported in part by NIH Grant HD22614. I am grateful to Claudia Brugman, Kathy Carey, Sandy Chung, Jeff Elman, Janet Fodor, Helen Goodluck, Mary Hare, Yuki Kuroda, Marta Kutas, George Lakoff, Ron Langacker, Diane Lillo-Martin, Steve Pinker, Steve Poteet, Karen van Hoek, Cyma Van Petten, and members of the PDP/Natural Language Processing group at UCSD for useful comments and suggestions.

[1]The first condition of the Functional Principle also provides a neat account of the following well-known contrast, first noted in Kuno (1973), which does not appear to follow from referential specificity: extraction of an entire prepositional phrase out of an island is generally better than extraction of the prepositional object alone with preposition stranding in the embedding.

(i) the man *to whom* I wonder what to give >
(ii) the man *whom* I wonder what to give *to* (Chomsky 1986b)

Stranding of the preposition in (ii) makes the reference of the argument expression in some sense dependent on the meaning of the function symbol, and as Keenan (1974:306) points out, the extent to which this is true makes the functional expression as a whole that much less acceptable.

[2]Frampton (1990) notes similar contrasts in the formation of parasitic gaps within relative clauses.

(i) Jack, who [*everyone* who likes *t*] visited *t*... >
(ii) Jack, who [*the man* who likes *t*] visited *t*...

[3]Note that examples (i) and (ii) below show relatively felicitous extractions out of NP PP constructions with fully referential head nouns, whereas (iii) is bad.

(i) It's the front door that I have *the key* to. =
(ii) It's Macy's that I know *the clerks* at. >
(iii) It's the front door that I know *the man* at. (Bolinger 1972)

The reason is that in (i) and (ii) the head noun is an 'attribute', in Kuno's (1987) terms, or an 'integral part', in Erteschik Shir's (1981) terms, of the extracted NP, and hence semantically subordinate to it. In terms of the Functional Principle, this means that only one fully independent reference is required. This is not the case in (iii), where the relationship of *the man* and *the door* is more circumstantial, and two independent references are required.

[4]I am indebted to Knud Lambrecht for this observation.

References

Bolinger, Dwight. 1972. *What Did John Keep the Car that was In? Linguistic Inquiry. 3.109-14.

Cattell, Ray. 1984. Composite Predicates in English. (Syntax and Semantics, 17.) Orlando: Academic Press.

Centineo, Giulia. 1986. A Lexical Theory of Auxiliary Selection in Italian. Davis Working Papers in Linguistics. 1.1-35.

Chomsky, Noam. 1973. Conditions on Transformations. A Festschrift for Morris Halle, ed. by Stephen R. Anderson and Paul Kiparsky, 232-86. New York: Holt, Rinehart and Winston.

Chomsky, Noam. 1986a. Barriers. Cambridge: MIT Press

Chomsky, Noam. 1986b. Knowledge of Language: Its Nature, Origin, and Use. New York: Praeger.

Chung, Sandra and McCloskey, James. 1983. On the Interpretation of Certain Island Facts in GPSG. Linguistic Inquiry. 14.704-13.

Cinque, Gugliemo. 1989. 'Long' Wh-movement and Referentiality. paper presented at the Second Princeton Workshop on Comparative Grammar. Princeton.

Cinque, Gugliemo. 1990. Types of A'-Dependencies. Cambridge: MIT Press.

Culicover, Peter W. and Wilkins, Wendy K. 1984. Locality in Linguistic Theory. Orlando: Academic Press.

Di Sciullo, Anna Maria and Rosen, Sara Thomas. 1990. Light and Semi-light Verb Constructions. paper presented at the Fifth Biennial Conference on Grammatical Relations. UCSD. La Jolla.

Dowty, David R. 1979. Word Meaning and Montague Grammar. Dordrecht: Reidel.

Dubinsky, Stanley. 1990. Light Verbs and Predicate Demotion in Japanese. paper presented at the Fifth Biennial Conference on Grammatical Relations. UCSD. La Jolla.

Engdahl, Elisabet. 1983. Parasitic Gaps. Linguistics and Philosophy. 6.5-34.

Erteschik Shir, Nomi. 1977. On the Nature of Island Constraints. Bloomington: Indiana University Linguistics Club.

Erteschik Shir, Nomi and Lappin, Shalom. 1979. Dominance and the Functional Explanation of Island Phenomena. Theoretical Linguistics. 6.41-86.

Erteschik Shir, Nomi. 1981. More on Extractability from Quasi-NPs. Linguistic Inquiry. 12.665-70.

Fodor, Janet Dean. 1978. Parsing Strategies and Constraints on Transformations. Linguistic Inquiry. 9.427-73.

Frampton, John. 1990. Parasitic Gaps and the Theory of Wh-Chains. Linguistic Inquiry. 21.49-77.

Francis, W. Nelson and Kučera, Henry. 1982. Frequency Analysis of English Usage: Lexicon and Grammar. Boston: Houghton Mifflin.

Friederici, Angela D. 1985. Levels of Processing and Vocabulary Types: Evidence from On-Line Comprehension in Normals and Agrammatics. Cognition. 19.133-66.

Gentner, Deidre. 1981. Some Interesting Differences Between Verbs and Nouns. Cognition and Brain Theory. 4.161-78.

Goldsmith, John. 1985. A Principled Exception to the Coordinate Structure Constraint. Papers from the General Session at the Twenty-First Regional Meeting of the Chicago Linguistic Society. ed. by William H. Eilfort, Paul D. Kroeber, and Karen L. Peterson. CLS 21, part 1.133-43. Chicago: Chicago Linguistic Society.

Grimshaw, Jane and Mester, Armin. 1988. Light Verbs and θ-Marking. Linguistic Inquiry. 19.205-32.

Kearns, Kate. 1988. Light Verbs in English. ms. MIT. Cambridge.

Keenan, Edward L. 1974. The Functional Principle: Generalizing the Notion of 'Subject Of'. Papers from the Tenth Regional Meeting of the Chicago Linguistic Society, ed. by Michael W. La Galy, Robert A. Fox, and Anthony Bruck. CLS 10.298-309. Chicago: Chicago Linguistic Society.

Kluender, Robert. in preparation. Semantic Barriers to Extraction: A Processing Account of Island Constraints. The Psycholinguistics of Island Constraints, ed. by Helen Goodluck and Michael Rochemont. Dordrecht: Reidel.

Kuno, Susumu. 1973. Constraints on Internal Clauses and Sentential Subjects. Linguistic Inquiry. 4.363-85.

Kuno, Susumu. 1976. Subject, Theme, and the Speaker's Empathy -- A Reexamination of Relativization Phenomena. Subject and Topic, ed. by Charles N. Li, 418-44. New York: Academic Press.

Kuno, Susumu. 1987. Functional Syntax: Anaphora, Discourse and Empathy. Chicago: University of Chicago Press.

Kutas, Marta and Hillyard, Steven A. 1980a. Event-Related Brain Potentials to Semantically Inappropriate and Surprisingly Large Words. Biological Psychology. 11.99-116.

Kutas, Marta and Hillyard, Steven A. 1980b. Reading Senseless Sentences: Brain Potentials Reflect Semantic Incongruity. Science Washington D.C. 207.203-5.

Kutas, Marta and Hillyard, Steven A. 1983. Event-Related Brain Potentials to Grammatical Errors and Semantic Anomalies. Memory and Cognition. 11.539-50.

Langacker, Ronald W. 1987. Foundations of Cognitive Grammar: Theoretical Perspectives. vol. 1. Stanford: Stanford University Press.

Maling, Joan and Zaenen, Annie. 1982. A Phrase Structure Account of Scandinavian Extraction Phenomena. The Nature of Syntactic Representation, ed. by Pauline Jacobson and Geoffrey K. Pullum, 229-82. Dordrecht: Reidel.

McClure, William. 1990. A Lexical Semantic Explanation for Unaccusative Mismatches. paper presented at the Fifth Biennial Conference on Grammatical Relations. UCSD. La Jolla.

Pelletier, Rosanne. 1990. Light Verbs in Telugu: A Clause Union Analysis. paper presented at the Fifth Biennial Conference on Grammatical Relations. UCSD. La Jolla.

Pesetsky, David. 1987. Wh-in-Situ: Movement and Unselective Binding. The Representation of Indefiniteness, ed. by Eric Reuland and Alice G.B. ter Meulen, 98-129. Cambridge: MIT Press.

Pinker, Steven. 1989. Learnability and Cognition. Cambridge: MIT Press.

Rizzi, Luigi. 1982. Violations of the Wh Island Constraint and the Subjacency Condition. Issues in Italian Syntax, ed. by Luigi Rizzi, 49-76. Dordrecht: Foris.

Rizzi, Luigi. 1989. Relativized Minimality. Cambridge: MIT Press.

Ross, John Robert. 1967. Constraints on Variables in Syntax. Bloomington: Indiana University Linguistics Club.

Ross, John Robert. 1987. Islands and Syntactic Prototypes. Papers from the General Session at the Twenty-Third Annual Regional Meeting of the Chicago Linguistic Society, ed. by Barbara Need, Eric Schiller, and Anna Bosch. CLS 23, part 1.309-20. Chicago: Chicago Linguistic Society.

Sells, Peter. 1989. More on Light Verbs and θ-Marking. ms. Stanford.

Van Petten, Cyma and Kutas, Marta. to appear. Influences of Semantic and Syntactic Context on Open and Closed Class Words. Memory and Cognition.

Van Valin, Robert D., Jr. 1987. The Unaccusative Hypothesis vs. Lexical Semantics: Syntactic vs. Semantic Approaches to Verb Classification. Proceedings of the 17th Annual Meeting of the North Eastern Linguistic Society. Amherst.

Van Valin, Robert D., Jr. to appear. Semantic Parameters of Split Intransitivity. Language.

Vendler, Zeno. 1967. Linguistics in Philosophy. Ithaca: Cornell University Press.

Zaenen, Annie. 1988. Unaccusatives in Dutch and the Syntax-Semantics Interface. CSLI Report No. 123. Stanford.

Zaenen, Annie. 1989. Unaccusativity in Dutch: an Integrated Approach. ms. Xerox-PARC/CSLI-Stanford.