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Psychology of Clefts II: Methodology[1]

Judy Delin
Centre for Cognitive Science
University of Edinburgh
2 Buccleuch Place
Edinburgh, U.K.
Tel: +44 31 668 4515
email: J.Delin@ed.ac.uk

This note outlines possible experimental paradigms for an investigation of how cleft constructions are processed psychologically. It examines lexical priming, self-paced reading tasks, and eye tracking in particular, concluding that the self-paced reading paradigm is the most promising for a large study, but suggesting a possible supplementary experiment using eye tracking. The background to the experiments is explained fully in Delin [1990a]; a briefer (but nevertheless adequate) justification is provided here.

1 Introduction

This note is intended to further the discussion of the experiments proposed in Delin [1990a] (the Blue Book note preceding this one) by suggesting some possible methods for the investigation. Before going into the methods, however, I should first of all make clear the nature of the phenomena I am interested in, and the reasoning behind the proposed hypotheses.

I have argued elsewhere (Delin [1989, 1990a]) that cleft constructions such as those in (1) derive part of their discourse function from the fact that they are PRESUPPOSITIONAL. That is, they contain or convey a semantic presupposition that can be predicted from their syntactic form[2]. In this way, all three clefts in (1) (an *it*-cleft, a *wh*-cleft, and a reverse *wh*-cleft respectively) would be expected to convey a presupposition that can be glossed as (1d):

(1) a It was the tyre that Mike kicked.
b What Mike kicked was the tyre.
c The tyre was what Mike kicked.
d Miked kicked something.

Note that this notion of presupposition does not depend on context (except for certain well-defined situations, see footnote), and is not dependent on the hearer's knowledge, beliefs, discourse model, or any such notion, at the time of encountering the presupposed information. Therefore, in most contexts in which any of the clefts in (1) could appear, we would expect the presupposition to be the same. (2) presents a variety of contexts, for example, in which (1a) could appear; the presupposition glossed as (1d) would persist in each case:

(2) a A: What did Mike kick?
B: It was the tyre that Mike kicked.
b A: Why did Bill kick the tyre?
B: He didn't. It was the tyre that Mike kicked.
c A: Why did Mike let down the tyre?
B: He didn't. It was the tyre that Mike kicked.

The notion of cleft presupposition as invariant with respect to context is required in an explanation of cleft constructions for the following reason. In clefts, it is possible to use the presupposition to convey information that is already known and understood between the conversational participants. This is the situation that many people expect to be the usual case (in fact, it is not the most common), and is exemplified in (2a). It is also possible, however, to use the presupposition to convey information that is partly or wholly new to the hearer (as in (2b) and (2c). Speakers do this for a variety of reasons (cf. Prince [1978] and Delin [in preparation]); it is, however, extremely common practice (see Delin [1989] for a description of a corpus of data showing frequencies of such examples). The important point to note here, however, is that, while information structure (as in what is already retrievable

[2]There are contexts in which these presuppositions would not survive, such as conditional and modal contexts, but these are not relevant here.

by the hearer, and what is new to them) is variable in clefts as in other sentence types, cleft presupposition as defined on the basis of syntax has a different role to play in the comprehension of clefts, regardless of the nature of the information it carries. As I argue in Delin [1989], cleft presuppositions have an important role to play in signalling to hearers the kind of processing that is required for the cleft construction.

My suggestion with respect to the processing of cleft constructions is that, regardless of the context of the discourse in which it appears, the presupposed content of the cleft forms *the information with respect to which the rest of the cleft's content is integrated into the discourse model.* This is suggested to be invariant, regardless of context.

An important point to note for understanding the experimental designs to be suggested below is that clefts of different kinds present information in different orders. *It*-clefts and reverse *wh*-clefts present the presupposed information *after* the rest of the information in the cleft (henceforward, we term the non-presupposition-bearing part of the cleft the cleft HEAD, and suggest that it conveys ASSERTED information). *Wh*-clefts, on the other hand, present this information *first.* If the presupposition is to be integrated first, these differences in ordering will have observable effects on processing: a processing load should result from the temporary storage of the asserted information while the presupposed information that is the key to its integration into memory is awaited. This prediction is central to much of the discussion of experimental design that appears in section 2 onwards.

The experiments suggested, then, are intended to test the view that the strategies adopted by hearers and readers for processing clefts are based primarily on *syntactic* cues. Clark and Haviland's [1977] discussion of clefts in relation to their 'Given-New Contract' view of utterance processing seems to suggest that hearers and readers process clefts presupposition-first because they know this part of the sentence to contain Given information. In cases where the presupposition does not contain Given information (as in some of the examples presented above), Clark and Haviland suggest that alternative processing strategies are adopted: hearers may, for example, attempt to find Given information elsewhere in the sentence, and integrate this first, or they may attempt to form an inferential 'bridge' for the presupposed information. I have shown elsewhere (Delin [1990b]) that a great many clefts have the information structure that Clark and Haviland suggest should be catered for by the backup 'error condition' strategy of bridging or restructuring. For this reason, it is tempting to suggest that hearers are not processing clefts presupposition-first because they have any particular expectations about the information structure of that cleft (for example, that they will be able to find an antecedent for the information currently in their model of the discourse), but because the presupposition itself is a signal for prior integration into semantic memory, regardless of its content. Evidence for this view is that the vast majority of reverse *wh*-clefts have the opposite information structure to that which Clark and Haviland claim to be the expected structure: they present Given information in the cleft head, and New in the presupposed part, as in (3):

(3) Horses. Of course—*that's what I* MEANT.

It is actually unclear what Clark and Haviland's strategy predicts for such cases: the anaphoric *that* is a clear indicator of Given information, which the hearer or reader will encounter first on processing the sentence. However, the specific prediction for clefts given by Clark

and Haviland is that Given appears in the cleft presupposition, and it is this part that will be integrated first—there are therefore two conflicting signals of Given information. These experiments are designed to find out what happens in such cases: do hearers and readers obey the syntactic signal, and integrate presupposition-first, or the information structure signal, which suggests that the reverse *wh*-cleft needs to be integrated head-first (on the basis of the vast majority of examples that the hearer/reader will have encountered)? If subjects adopt the former strategy, we will know the function of the cleft presupposition: it is a signal to integrate first. If they adopt the latter strategy, we will know that information structure relative to the hearer/reader's discourse context is the most powerful cue as to how to integrate sentence content into memory.

2 Hypothesis and Predictions

The main hypothesis that is being dealt with, then, is as follows:

Hypothesis: in the processing of cleft constructions, the presupposed proposition is the information which is integrated first into semantic memory. The rest of the content of the cleft will be integrated only after this has been done.

We can break down the investigation into three predictions, each of which might be tested in a separate experiment:

- The presupposed proposition should be integrated first regardless of the order of presentation in the sentence—for example, whether the cleft presents the presupposition first or second.
- In cases where the presupposition is postponed within the syntactic structure, the sentence as a whole should be harder to process.
- The presupposition should be integrated first regardless of the status of the presupposed information relative to the hearer/reader's existing knowledge or existing model of the discourse—for example, even if the presupposition is new to the hearer/reader.

Several experimental paradigms have been examined as possible means of testing the above predictions. These have been as follows:

- Lexical priming
- Self-paced reading
- Eye tracking

In fact, the data have proved particularly difficult to deal with. This note, therefore, details the present state of my thinking on possible paradigms, but does not yet offer a single solution.

3 The Lexical Priming Paradigm

The lexical priming paradigm, in which the information integrated into memory can be observed to facilitate related words, appeared to be the most promising for examining the prediction that the presupposition contained in the cleft was integrated prior to the asserted information. If this were the case, we would expect lexical items related to the presupposed information to be facilitated first, while those related to the asserted information were not.

This section points out several problems with the priming paradigm for clefts. Some are due to the nature of the clefts data, and may be superable. One, however, appears to be fatal (although I would welcome suggestions to the contrary). The problems are, briefly, as follows:

- Can the priming paradigm differentiate between short-term storage of information and information fully integrated into long-term semantic memory?
- Can suitable stimuli be constructed, given the clefts' requirement for coherence with preceding context in order to be acceptable?
- Can priming tell us enough about what happens *at the time of processing the cleft*, given the nature of the connection between the cleft and the context that may already exist?

I will deal with each problem in turn.

First of all, in order to use the priming paradigm at all for testing predictions such as those made above, we have to make the following assumption:

Assumption: Information is only primed by information fully integrated into semantic memory, and not by information temporarily placed in short term storage.

This is relevant for clefts in that two out of the three cleft types present asserted information *first*: the prediction here is that this information is held temporarily while the presupposition is sought. If short-term storage also causes priming, we will not be able to use priming as a method for spotting potential differences between presupposed and asserted information. I do not know at the time of writing whether it is justified to assume that priming is able to differentiate between the two types of storage: if it is not, then it is not a suitable basis for the experiments.

The construction of suitable stimuli for use in a priming task is another problem area. First of all, it is assumed that it will always be necessary to present some kind of context—such as one or more sentences, or a picture—prior to the presentation of the cleft examples in the task. This is because the processes we are trying to observe concern the on-line construction of a model of discourse, which, arguably, is not what is taking place in an experimental situation where single sentences are presented. However, this assumption does leave us with a problem, particularly acute in the case of clefts.

For a priming task to work, it is important to make sure that the information that is being presented in the cleft as a whole is not already primed by (or even explicitly presented in) the previous context. If the information is primed in this way, it could be argued that the context, and not the cleft content, is causing any priming effects observed in the experiment. Unfortunately, cleft constructions have a particular requirement that they should manifest coherence relationships with previous discourse, otherwise they themselves are unacceptable. This means that it is very hard, if not impossible, to construct examples in which the clefts are both suitably unconnected to previous context for the requirements of the priming task, and suitably connected to make for acceptable mini-discourses as stimuli.

The particular constraints on clefts are:

- *Wh*-clefts don't like to contain information that is completely unrelated to previous context in the *wh*-clause (the presupposed part, such as *what my name is* in *what my name is is Ellen*). It is therefore not possible to present unrelated information in the presupposition of a *wh*-cleft, leading to the possibility that information contained in this part of the cleft will already be facilitated by the time the cleft is encountered.
- *It*-clefts and reverse *wh*-clefts are more tolerant in the information structures that appear, but as with all clefts there exists a MINIMAL COHERENCE REQUIREMENT (cf. Delin [1989:215]) to the effect that either the cleft head may specify a New element, or the cleft presupposition may specify a New eventuality, but no cleft can do both at the same time.

Some examples of how these facts cause problems for priming may help at this point. In the following examples, C stands for *context*, and S stands for *stimulus*. In (4), where the context is sufficiently bland in order not to bias the observation of priming effects on various parts of the succeeding clefts, it is clear that clefts devised are at best marginal in their acceptability:

(4) C: Something is happening in the picture.
S: ?It is a cat that's stuck up a tree.
S: # What's stuck up a tree is a cat.
S: # A cat is what is stuck up a tree.

However, biasing the context so that it provides sufficient antecedent anchorage for the clefts to be acceptable results in stimuli in which elements related to the 'anchored' part can be expected to be primed already, thereby invalidating any comparison of priming between parts of the clefts:

(5) C: Something is stuck up a tree.
S: It is a cat that's stuck up a tree.
S: What's stuck up a tree is a cat.
S: A cat is what is stuck up a tree.

Note that sufficient anchorage can be supplied by the context in a variety of ways: C in (5) could equally have been *a cat is stuck somewhere* or *something is stuck somewhere*, for example. In each case, the problem is the same.

The above may mean, conceivably, not that the construction of priming stimuli is impossible, but that it is merely difficult. However, there is a further objection to the priming paradigm for clefts. There is a school of thought that suggests (although I do not currently subscribe to it) that *all* clefts have to have antecedents of some kind for their presupposed information, otherwise they will not be acceptable in the discourse. An antecedent can be an entire and identical proposition, or it can be something rather looser, such as a proposition inferrable from general principles of world knowledge. Suppose that I had performed priming experiments on clefts, and found that the presupposed information caused priming of related elements before the asserted information did. Now, if it is true that cleft presuppositions always have antecedents in context, it is arguably the case that the presupposed information *already has elements related to it primed before the cleft is even encountered.* The priming results of the experiment could not therefore be construed to indicate anything about what is happening in terms of the order of integration of information in the cleft: even if the presupposition were integrated second (contrary to the predictions I have made), the presupposition would apparently prime related elements first, since that content would already be present in context.

It is this third objection that is the most telling, and which leads me to reject the priming paradigm as a suitable means of analysis for clefts. However, one possible means of avoiding these difficulties is the use of **decontextualised examples** as stimuli. These, of course, have none of the problems attendant on the relationship between the cleft and the context, but it is not clear to me whether they are realistic indicators of the integrative processes that I am trying to access: one strategy, for example, would be to try to store the entire surface string in short-term memory, rather than try to integrate it at all. If it were a risk that the paradigm would promote these strategies, then decontextualised examples are not suitable data for the experiment.

4 Self-Paced Reading Tasks

The main concern of this study is not to find how hard sentences are to process in general, but to find out how the processing load changes at various points in processing. Self-paced word-by-word reading seems to be a promising paradigm for this study, since it is particularly good at indicating the processing load exerted by comprehension at a variety of points in the sentence.

In what follows, I will sketch briefly how each of the three predictions drawn from the main hypothesis might be investigated. First, however, I will outline some general points about the design of experiments in this paradigm.

The first point is that the problems of presenting a sentence of context prior to the cleft sentence will be the same as those noted in section 3 (difficulties of finding a context sufficient to allow acceptable clefts, without biasing the task to be performed). It is assumed here that the sentences for self-paced reading will be presented in isolation for the first two experiments, although context will need to be introduced for the third. As noted above, neither situation is without its problems.

Second, a self-paced reading task would be expected to reveal parts of the sentence at which processing is slowing down, and parts where it is proceeding more quickly. The main hypothesis predicts that, when the presupposition is introduced second, the asserted information will have to be held in short-term memory temporarily. This storage should produce a processing load, resulting in slower overall comprehension of the sentence. Furthermore, we should expect a drastic slowing down at the point of the sentence at which integration of the asserted information is taking place—presumably once the presupposed information has finally been integrated.

There are two points to make in relation to this. The first is that this 'resolution' processing load (cf. Stenning [1986]) is predicted to happen at a clause boundary, since the presupposed information constitutes a clause in its own right. It may then be difficult to separate this effect from a normal 'clausal processing effect', which is predicted to take place at clause boundaries. However, the two may in fact be the same thing—it isn't currently clear to me whether or not this is a problem. The second point is perhaps more serious: should we really expect integration of the asserted information with the presupposed information to happen after the presupposed information has been completely processed, in every case? The reason for the question is that cleft sentences can contain syntactic gaps in various places—for example, either subject, object, or prepositional complement position—and it may be the case that resolution takes place not after the presupposition, but at the place at which the gap indicates a complement of information is required to complete the proposition being processed. For example, I might assume that the resolution takes place right at the end of each of the clefts in (6); it may, on the other hand, take place in the gap positions, indicated in each case by *t*:

(6) a It was John who *t* ate the beans.
b It was John who I ignored *t*.
c It was the watch I gave *t* to father.
d It was to father I gave the most attention *t*.

In each of the cases above, the head element (*John, the watch, to father*) is required to complete the presupposed proposition in a different place. Would this affect the results of self-paced reading tasks? If this paradigm is adopted, it would perhaps be wise to stick to the most common type of cleft, where the subject is cleft head (as in (6a)), rather than mixing the stimuli.

4.1 Experiment 1: Is Presupposition Integrated First?

The hypothesis predicts that in clefts of equivalent content, those that allow an incremental model to be built up will be processed faster than those that present information in a manner that interrupts this process. In other words, clefts that present presupposition first will be processed faster in general than clefts that present it second. This means that *it*-clefts such as (7a) and reverse *wh*-clefts such as (7c) will be slower to process than *wh*-clefts such as (7b):

(7) a It was the table that fell over.

b What fell over was the table.

c The table was what fell over.

However, it is not clear that *it*-clefts are comparable in degree of syntactic complexity to the two types of *wh*-cleft, and so we will not be able to use absolute comparisons of speed across the three cleft types. A more sensible comparison is offered by the two types of *wh*-cleft, and a reading-time comparison could be performed on examples such as those above. It could be predicted that not only would the reverse *wh*-cleft take longer to process, but where the increased processing time would appear: we would expect (modulo the discussion of syntactic gaps, above) a greater end-clause processing load due to the integration of *the table* at the end of the sentence. In addition, we would expect a slightly increased processing time over the clause *what fell over* as a whole, reflecting the load placed on short-term memory by the temporary storage of *the table*.

Due to problems of familiarity effects if both versions of the same content were presented to the same subject, we would have to present one version to some subjects, and some to others.

4.2 Experiment 2: Does Presupposition Postponement Increase the Load?

If, as predicted, the storage of the content of the cleft head (for example, *the table* in the examples above) causes an increase in processing load in cases where it is presented prior to the presupposition, we would expect a greatly increased effect in examples where the head is a complex constituent. That is, we would expect cases such as (8a) to place a much greater load on the processor than cases such as nextexb. The storage of the complex constituent or its content should place a much greater load on short term memory, thereby reducing the available capacity for comprehending the rest of the sentence.

(8) a The horrible cracked green vase with the gilded rim that used to be on the diningroom table was what fell over.

b The vase was what fell over.

Comparison of sentences such as (8a) with *wh*-clefts such as (9) should produce a result that is a more dramatic version of the result of experiment 1: namely that processing load increases greatly as the first part of the cleft is processed, and slows down processing for the rest of the cleft. A large integration effect should be noticeable at the end of the cleft. There should be no such effects for the *wh*-cleft, which should on this hypothesis allow the representation to built up incrementally.

(9) What fell over was the horrible cracked green vase with the gilded rim that used to be on the diningroom table.

4.3 Experiment 3: Is the Effect Maintained Regardless of Context?

This third part of the study concerns whether the processing effects observed so far are constant regardless of information status—in which case we can ascribe them to the syntax of the clefts—or whether they change. It will obviously be necessary to use contextualised stimuli for this part of the study.

There are several points to watch when constructing stimuli for this experiment. First of all, it is well known that the difficulty or otherwise of resolving anaphoric reference (pronoun or definite NP) contributes to the rate of processing of the sentence as whole. For this reason, we should be careful to note the following:

- Unlikely pronoun resolutions add to processing time. These should be avoided, or at least matched in all the stimuli.
- Pronoun resolution is also affected by (at least): the case roles of antecedent and anaphor; the distance between antecedent and anaphor and the topic-maintaining or topic-shifting nature of the intervening text; and the grammatical position of the antecedent.
- The kinds of entities introduced by different NPs take different amounts of time to process. Type mismatches in the referents of NPs across stimuli will therefore bias the comparability of the results.

A second, related point to watch is the THEMATIC STRUCTURE of the mini-discourses produced. From studies of REFERENTIAL CONTINUITY in texts (cf. Ehrlich and Johnson-Laird [1982]), it is known that texts that preserve close co-referential links are easier to process than those that interrupt the dependencies between co-referential expressions. We can conclude from this that changes in referential continuity between ostensibly comparable stimuli will bias reading times considerably. This is a sizeable problem for construction of stimuli of this nature, since comparisons of two of the constructions we are interested in—the *wh*-cleft and the reverse *wh*-cleft— will create precisely the kind of contexts in which differences in referential continuity can most clearly be observed. For example, given the context C below, the referential relation *a man ... he* that holds between C and the *wh*-cleft (10a) is predicted by Ehrlich and Johnson-Laird's findings to be easier to process than the same referential relation between C and (10b), because of the intervening reference to *a pole* in the second case:

(10) C: There's a man in the picture.
  a S: What he's carrying is a pole.
  b S: A pole is what he's carrying.

From other studies, it is known that these difficulties in processing increase if the intervening material contains or constitutes a potential antecedent for the subsequent pronoun, thereby rendering it ambiguous. However, thematic effects do not depend on pronominalisation: co-reference can take place in a variety of ways, and so the difficulties do not disappear if

pronouns are avoided. For example, in (10), we could replace *he* with *the man* in each of the clefts, and the thematic effects will persist.

Because it seems that thematic effects will appear of necessity if textual contexts are used as a background for comparing the clefts, it would be better to use pictures as contexts. Since pictures do not present information in any marked serial order (although there may well be common strategies for scanning pictures), a single-frame context could not be supposed to present a thematic bias towards ease of processing in either cleft arrangement.

The first part of the experiment could consist of the presentation of a picture, such as a simple drawing of a man carrying a box. In the first condition (the OLD-PRESUPPOSITION Condition), where the presupposed part of the cleft should contain material that is given in the context, one of the following should be presented to each subject:

(11) a What the man is carrying is a box.
b A box is what the man is carrying.

In the second condition (the NEW-PRESUPPOSITION condition), we need the presupposed information to have no antecedent in the context. We could therefore present a general statement after the picture, such as one of the following:

(12) a What everyone wants is a box.
b A box is what everyone wants.

In each case, it cannot be supposed that the proposition *everyone wants something* is already available in the context (although it could be said to be inferentially related in some sense, it is not in any way currently salient).

In the New-Presupposition condition, we would expect the general relationship between the processing times of the two types of construction to be preserved—that is, the reading times at each point in the sentence should be comparable to those in the Old-Presupposition condition. If they are not, it will reveal that subjects change strategies on processing clefts with different information structures—it will perhaps reveal a bias towards integrating information Old-first, and so we will expect *a box* in (12) to be integrated first in both cases, instead of in the reverse *wh*-cleft case (12b) being stored short-term in order to wait for the presupposition. If, however, strategies do not change, we will know that subjects are still waiting for the presupposed information to use this as an anchor for integrating the rest of the content, regardless of the information status of the presupposition. Such a result would confirm the initial hypothesis.

The design of the third phase suggested here duplicates that of the first experiment mentioned in this section to a certain extent, in that the first condition (Old-Presupposition) of the experiment just described repeats the exploration of the basic processing of *wh*-clefts and reverse *wh*-clefts. We might therefore think of amalgamating the first condition of experiment 3 with experiment 1. Arguments against this are that the first experiment examines the processing of clefts out of context, and therefore abstracts away from the problem of how

information structure relative to a discourse context affects processing.

5 Eye Tracking

Eye-tracking is still quite a novel paradigm, but there are indications that it is now possible to use eye-tracking data as supplementary data in a study of the integration of information into memory. It is known that the length of time that subjects fixate on words is related both to lexical access and to semantic processing (cf. Rayner and Frazier [1989]; Schustack, Ehrlich and Rayner [1989]). Although it is hard to tease the two apart, it is still possible that eye movement records can tell us something about the processing of clefts.

Because of the inherent complexity of the experimental method, a simple task is suggested for examining the processing of clefts: a comparison of matched pairs of *wh*-clefts and reverse *wh*-clefts. On the basis of the hypothesis stated in section 2 above, we would expect to find differences in the lengths of subjects FIXATIONS (pauses in eye movement) at various points in the sentences. Since we are suggesting that integration of the information in short-term memory happens only after the presupposed information has been integrated in reverse *wh*-clefts, we would expect a long end-of-sentence fixation while that integration is taking place. In *wh*-clefts, which we hypothesise to allow the integration of information to take place serially and without interruption, we would predict a shorter end-of-sentence fixation. There may be additional end-of-clause fixations between constituents within either sentence types, but the end-of-sentence effect should be the major one.

In the processing of reverse *wh*-clefts, we might expect a REGRESSION back to the initial constituent of the cleft to occur at the point at which the reader has to integrate that information into the discourse context.

Of course, in interpreting the eye movement record, and in constructing stimuli for eye tracking experiments, there are many pitfalls to watch out for (cf. Rayner *et al* [1989]). A few of them are as follows.

In the construction of stimuli, it is important to control for the possibility of words being **skipped**. This appears to occur as a function of wordlength (cf. Rayner and Duffy [1988]) and whether the word is a function word or a content word (Carpenter and Just [1983]). According to Rayner *et al*'s interpretation of the facts, words of less than or equal to three letters are usually skipped, words of six letters are fixated most of the time, and words of equal to or greater than eight letters are usually fixated. The interaction between content/function and wordlength means that content words are more likely to be fixated than function words, and long content words are much more likely to be fixated than short function words.

It is also important to note that exactly what a subject is looking at during a fixation cannot be pinpointed down to a single word. **Perceptual span** is reported by Rayner *et al* to stretch from near the beginning of the currently fixated word to anything up to 15 characters to the right; word identification, however, is reported to occur over a smaller span than this, up to approximately 7 characters to the right. This usually means that subjects have to move to a

new fixation to identify each new word, except in cases where two or three short words occur together, where all three can be identified in the single fixation. This, like the facts regarding skipping, means that there is not necessarily a one-to-one mapping between the number of words and the number of fixations.

It is not necessarily the case that long fixation times mean heavy semantic integration processes are going on: it is impossible to separate the effects of **lexical access** from those of semantic processing. Lexical access times are known to increase in inverse relation to the frequency of the fixated word (cf. Inhoff and Rayner [1986], Rayner and Duffy [1986]). It is also documented that fixation times on the word to the right of a low-frequency word will also be increased, which Rayner *et al* suggest may be due to readers not previewing this next word during the current fixation due to the increased processing required by lexical access.

A controversy also exists concerning how to measure processing time using the eye movement record as a basis. One problem is that subjects may perform **multiple fixations** within a short space of time. Some researchers prefer to use the evidence from the first fixation, dismissing other close ones as noise; others prefer to use the second, assuming that the first was the result of the eye landing in a bad place. Others measure **gaze duration**, being the sum of the length of fixations (excluding any regressions). Rayner *et al*'s preferred strategy is to use a combination of these measures and look for consistency across them, reporting

- first fixation
- gaze duration conditionalised upon a fixation on a target word
- the probability of fixating the word
- frequency of regressions to the word

in order to provide a complete record.

Rayner *et al* also make comments on how to get results for a span of text bigger than a single word from the eye movement record. We would need to do this, since we are interested in the time taken to process the two main constituents of the cleft. The most common strategy (originated by Frazier and Rayner [1982]) is to divide the sentence into regions and examine the processing times for each region. This is done by summing all the left-to-right fixations (i.e. the non-regressive fixations) within the relevant region, add all the regressions within the region, and conclude processing is complete when the eyes pass out of the region (which means that regressions back into the region from outside are not included). A second pass provides the total gaze duration when subsequent re-readings are added on. To get a reading time per character, the reading times can be divided by the number of characters in the region, and for the total region reading time, this figure should be multiplied. Rayner *et al* note that this technique is not without its problems: such as the time spent travelling between fixations in regions which are long enough, or complex enough, to require multiple fixations. It also ignores possible effects from word frequency mismatches, which are not negligible.

If lexical access effects can be controlled for reasonably (e.g. by controlling for frequency, bigram and trigram frequency, prefixing, and predictability) it may well be possible to construct

a simple eye-tracking experiment for clefts. It may be best, however, to base the analysis of the data primarily on the word-by-word record, rather than relying on the problematic per-region reading time strategy described above.

6 Conclusion

On the basis of the discussion above, it seems as if the self-paced reading paradigm is the most promising one for a study of this type, perhaps with a smaller supplementary experiment using eye tracking. Comments are enthusiastically sought, however, both on the paradigms examined here, and on others which I may have overlooked but which may be suitable for the study suggested here.

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