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ABSTRACT

This paper explores the problem of reconciling general psychological processing constraints with linguistic constraints on discourse structure. Two types of psychological constraints, the 'immediacy constraint' and the 'limited focusing constraint' are shown to combine with linguistic constraints to determine the pattern of eye movements during reading in two case studies. Data suggest that (1) there is a role for both immediacy and limited focusing in parsing, and (2) lexical priming was evident, but could not account for subtler effects of contextual restriction that only appear when processing definite noun-phrases. Psychological and linguistic determinates of processing may interact in much more complicated ways than has been assumed. (Author/JP)

Reconciling the psychological with the linguistic in accounts of text comprehension

SIMON GARROD

Abstract

This paper explores the problem of reconciling general psychological processing constraints with linguistic constraints on discourse structure. Two types of psychological constraints are identified, the 'immediacy constraint' and the 'limited focussing constraint'. Both are shown to combine with linguistic constraints to determine the pattern of eye-movements during reading in two case studies. The first involves parsing locally ambiguous sentences in a discourse context, the second involves interpreting definite as opposed to indefinite noun-phrases in comparable contexts. The conclusion from this analysis is that the psychological and the linguistic determinates of processing may interact in much more complicated ways than was originally assumed in the early days of psycholinguistics.

1. Introduction

The discipline of psycholinguistics has a short history. It all began with the recognition in the late 1950s that natural language structures were far more complicated and opaque than had previously been assumed. Thus Chomsky's pioneering work in linguistics forced psychologists to confront directly the processing problems facing a language learner or language user. At first, it only seemed a matter of uncovering experimental evidence to confirm the psychological reality of this complex structure. Where clear discrepancies arose between the linguistic theory and the experimental observations these were accounted for in terms of the gap between a supposed abstract competence on the part of the language user and the vagaries of performance. So right from the start there was a recognition that language users are subject to general psychological performance constraints of limited memory and attention that may make their behaviour fall short of the theoretical ideal. For example, infinitely long sentences or even relatively short ones with deep centre embeddings were judged as clearly beyond human processing capacity while not being ruled out in principle by the grammar which we were supposed to hold in our heads.

But this honeymoon between the theoretical linguists and the experimental psychologists was not long lived. As the more detailed aspects of the linguistic theory were subjected to psychological tests, it became apparent that the gap between competence and performance was not to be bridged in terms of straightforward psychological constraints. The immediate consequence of this was a steady dissociation between the concerns of the two disciplines. On the one hand the

linguistic analysis became more abstract in relation to issues of language processing and on the other the psycholinguistic work came to reflect more and more the influence of general psychological competences in language processing. So, for instance, there was an increasing interest in the role of general knowledge, something which does not reflect linguistic competence narrowly defined. In turn this led to the view that language processing was really just another, albeit complicated, kind of problem solving of the sort that underlies much human rational behaviour. This divergence between the disciplines is still very much in evidence today. In particular the new 'connectionist' accounts represent an attempt to explain language learning and language processing in terms of powerful distributed processing systems which have no place for linguistic rules (Rumelhart and McClelland, 1986).

However, in this paper I will suggest that some recent work points to the development of a more mature relationship between linguistic analysis and the understanding of psychological process, but it is not such an imperialistic one. The first thing that has to be recognised is that there is a basic difference in the way the two disciplines have come to view what is at issue. The primary goal of the theoretical linguist has been to try and capture the structure of sentences in a general fashion, that is as objects removed from both their physical circumstances of interpretation and more general contexts of use. The psychologist on the other hand is concerned with establishing the details of the cognitive processes which occur when utterances are encountered in real time. So psychological accounts have to reflect the fact that understanding is not a discrete process which only happens after the sentence has been apprehended in full, but rather it is a continuous incremental process occurring as the information presents itself. Neither is comprehension something which happens in a vacuum, it clearly depends upon the state of the comprehension system at that time, and this forces us to take very seriously the role of context. So for the psychologist the linguistic object of investigation is already something quite different, it is both dynamic and contextually situated.

In itself this difference of viewpoint does not mean that linguistic principles of structural analysis have no bearing on the cognitive processes of comprehension, but it does make it less likely that there will be any straightforward connection between the two. So, for instance, what may be the most parsimonious account of sentence structure when the sentence is viewed as a whole and in isolation may not relate directly to the most parsimonious account of the process which has to interpret this structured input sequentially in real time and in a variety of different contexts (Marslen-Wilson and Tyler, 1981). In a similar vein, it may be methodologically more convenient to approach the linguistic analysis of syntactic structure independently of any analysis of the sentence's meaning or of its significance when situated in context,

yet from a psychological processing point of view there are good reasons for believing that all of these factors have to be taken into account simultaneously.

The approach which I shall take to the whole issue of how we might reconcile the psychological with the linguistic is therefore, to begin with, a more detailed discussion of what the psychological constraints are, and then consider how they might interact with linguistic form to determine the nature of the process.

2. The nature of psychological constraints in processing

Perhaps the most apparent psychological constraints come from the limitations of immediate memory capacity and attention span which we know to obtain. This means that there is a high cost on holding uninterpreted linguistic input for any length of time. In the first place any new input will compete for memory space and in the second place delaying interpretation risks committing the system to a processing debt which will have to be redeemed later as new information is flowing in and competing for attention. In other words, it is a good principle to match the rate and timing of any interpretation process as closely as possible to the rate and timing at which the input is being sampled, and thereby not risk falling behind the speaker. So one kind of constraint on the processing system concerns the immediacy of interpretation and as a consequence its inevitably sequential incremental nature. I shall refer to this as the 'immediacy constraint'.

A second somewhat different source of constraint, which is not so easy to pin down, comes from the fact that language comprehension is basically a process of mapping linguistic information (sound segments or letters, words, phrases, etc.) onto corresponding knowledge about the significance of this information. Consequently efficient interpretation requires fast access to knowledge which may not be readily retrievable at that moment in the process. This has led to the idea that there is some kind of special dynamic knowledge organisation system to support the immediate processing of expressions whose interpretation depends upon access to knowledge about the context. So, for instance, the immediate interpretation of definite noun-phrases or pronouns which require access to contextual information will be subject to constraints on this knowledge organisation system. I shall call this the 'limited focussing constraint' since it concerns the way in which limited amounts of knowledge may be made differentially accessible over the time course of understanding and so enter or leave the focus of attention.

Both the immediate processing constraint and the limited focussing constraint have important consequences for the way in which we understand text, which will interact with any influences of text structure, and it is only when we appreciate this that any

reconciliating between the psychological and the linguistic aspects of processing will be found. In this paper, I discuss two sets of experimental findings which point to the role of structure in processing, and serve as interesting case studies in reconciliation. The first relates to syntactic parsing and the second to the interpretation of definite as opposed to indefinite descriptions.

I begin with a general background discussion of some of the psychological issues which surround the problem of parsing sentences during comprehension. The discussion then turns to how accounts of parsing isolated sentences generalise to comprehension of those same materials situated in more realistic contexts.

3. The immediacy constraint and syntactic parsing

One aspect of language comprehension that has been the subject of much psycholinguistic investigation is the parsing of locally ambiguous sentence fragments such as the following:

(1) Mary took the cheese from the farmer .....

Such a fragment encountered in isolation has two possible readings; in one the prepositional phrase *from the farmer* attaches high in the sentence structure to the verb - it plays the semantic role of source - in the other reading the PP is taken to modify the NP *the cheese* so it attaches low. The thing that makes such structures interesting from a processing point of view is that they only present problems for a system subject to the immediacy constraint, since in most contexts of usage, the fragment will form part of a sentence which is not ambiguous as a whole. For instance it might read:

(2) Mary took the cheese from the farmer instead of from the grocery store.

or

(3) Mary took the cheese from the farmer out of her bag.

In (2) the structure of the sentence as a whole forces the PP to attach to the V as a source argument, while in (3) it must attach to the NP as a postnominal modifier.

A similar consideration applies to sentence fragments like:

(4) The woman rushed to the hospital .....

which might form part of the following:

(5) The woman rushed to the hospital had a beautiful baby boy.

in which the phrase *rushed to the hospital* acts as a reduced relative, or

(6) The woman rushed to the hospital to see her sick husband.

where it serves as the main verb of the matrix sentence. Again the sentence fragment in (4) only presents a parsing problem if the system is forced into making an immediate decision about its syntactic role as each word and phrase is encountered.

One possible processing solution might be to track both potential structures until the system encounters a point of clear disambiguation[1]. This would comply with the immediacy constraint while leaving open the options on final interpretation. However, it would fall foul of just the same attentional limitation that motivated the immediacy constraint in the first place, since it means having to attend to two potential interpretations at the same time. Just such deliberations as these, led to the proposal that readers or listeners should initially only track the 'preferred' interpretation of the sentence but be prepared to re-evaluate this interpretation in the face of subsequent evidence to the contrary, the so-called garden path model.

The issue then becomes one of providing a principled account for determining the syntactic preference in any of these situations. One solution, which has been proposed by Frazier and her colleagues, is to assume that the parser, when faced with such a decision always opts to build the simplest structure in the first instance, that is the structure which incorporates the least number of additional syntactic nodes. So among other things it will always promote what is called 'minimal attachment' for any new phrase (Frazier, 1987).

In fact there is now a considerable body of evidence that when such sentences are encountered in isolation, readers behave according to the garden path model and only adopt a 'minimal attachment' interpretation for the postnominals in the first instance. Thus if you track a reader's eye movements as they view a sentence such as (2) or (3) the fixation durations increase dramatically in the disambiguating region for (3) as compared to (2) and there is also a strong tendency for readers to refixate the ambiguous fragment in (3) as compared to (2) (Frazier and Rayner, 1982). The same kind of eye-fixation pattern can be observed in other syntactic environments where there is a contrast between minimal and non-minimal attachment, such as with the reduced relatives.

So here we seem to have a nice example where the processing account reflects in a rather direct way the linguistic analysis of the language. Principles of structural

simplicity seem to determine processing options in line with the cognitive constraints. But maybe this is jumping to the conclusion too quickly. After all, as was pointed out earlier, readers do not usually encounter sentences in isolation and it is maybe something about the strangeness of the context-free interpretation which is leading to the pattern of preference rather than syntactic simplicity.

In both example (3) and example (5) the non-preferred reading is the one where the ambiguous fragment plays the role of postnominal modifier for a definite NP. It could be argued that such uses of PPs or reduced relatives are only rhetorically motivated in rather special contexts where they aid the reader or listener in discovering an appropriate referent for the definite description. Thus if the reader knows from the context that there is some referent under the description "cheese from the farmer" or "woman who has been rushed to the hospital" then this might motivate an initial preference for the non-minimal attachment of the postnominal. In other words, it is quite possible that the eye movement results reflect what happens when a reader is presented with the sentence in a default context which does not support resolution of the definite description plus its modifier. If this were the case the fact that the results go along with a model based on preference for simple structure could just be coincidental and an artefact of the rather unnatural circumstances of these experiments.

In order to test this assumption Rayner, Garrod and Perfetti (in press) carried out an eye-tracking experiment designed to pit the discourse level preference for non-minimal attachment in appropriate contexts against the presumed immediate structural preference for minimal attachment. We did this by manipulating the referential context to either maximise the likelihood that the relevant antecedent information was in focus at the time of encountering the critical NP or not. So critical target sentences such as (2) and (3) were preceded by different context passages of the sort shown in Table 1. The non-minimal attachment sentence (3) could be preceded by a focussed antecedent context or a non-focussed antecedent context but in both cases containing an appropriate antecedent for the NP-PP complex, while the minimal attachment sentence (2) would always be preceded with a context consistent with that reading to act as a control.

Table 1.

Materials used in Rayner, Garrod and Perfetti (in press)

PP NMA Context

Mary usually tried to do the week's shopping on a Saturday morning. So she started out by going down the road, where she bought some delicious cheese from the local farmer. %She then went on into the village to the butcher for her meat and poultry, then on to the grocery store to buy vegetables and potatoes. % But today she had forgotten that she was having lunch with her mother and had to bring some food. *She decided to take the cheese from the farmer out of her bag to eat for their lunch.*

PP MA Context

Joan always had trouble choosing the best produce. She was extremely fussy about the quality of the food she bought, and this was a special lunch party that she had arranged. She had just been to the grocery store which had some very fresh looking cheese but wasn't sure if she couldn't do better at the farm. When she arrived there, *she decided to take the cheese from the farmer rather than the grocery store.*

Key. materials in % signs were included in the non-focus conditions and left out in the focus condition. The sentences in italics are the critical target sentences where the fixation durations were measured.

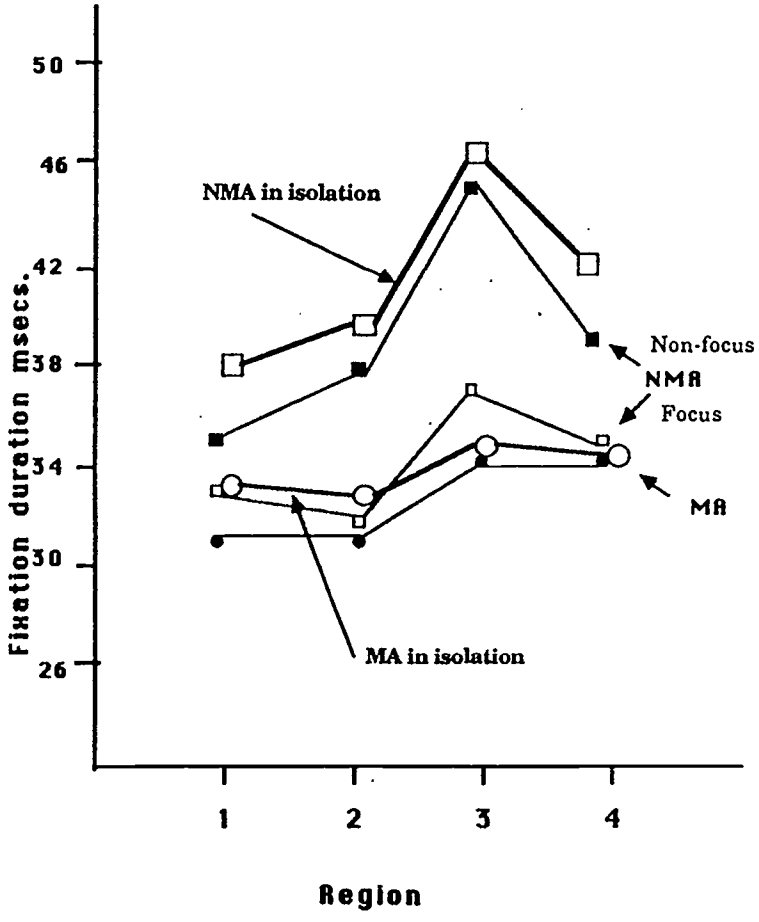
The pattern of eye fixations and regressions turns out to be particularly interesting when the sentences are put in context. First, the total gaze durations are shown in Figure 1 for the four critical regions of the sentences, exemplified below:

(2) Mary took /the cheese/ from the farmer /instead of from/ the grocery store.
1 2 3 4

(3) Mary took /the cheese /from the farmer/ out of her bag./.....
1 2 3 4

where these regions are defined as the following (1) is the NP, (2) the ambiguous PP fragment, (3) the disambiguating region and (4) the next region after that.

Figure 1.



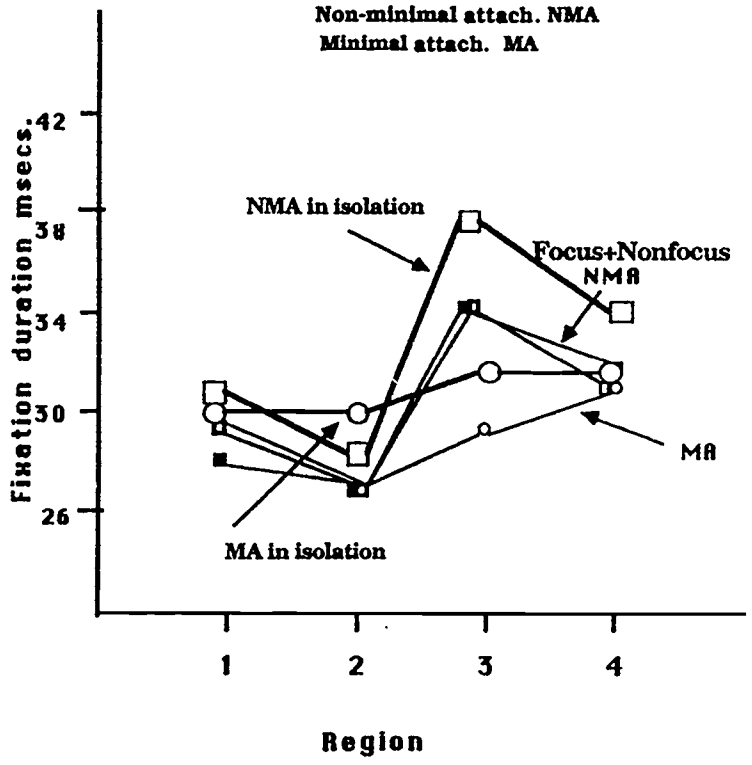
Total eye fixation patterns for the four regions in the critical sentences, when read in isolation and in either the Focus or the Non-Focus context conditions.

Looking first at the thicker lines on the figure we can see the gaze duration effects for sentences like (2) and (3) when read in isolation (MA in isolation and NMA in isolation). These results replicate the earlier findings discussed above. For the non-minimal attachment case readers spend much longer on the disambiguating region (region 3) and regress more often to regions 1 and 2 containing the NP and PP which is reflected in the additional total gaze durations for these regions. However, the interesting result which relates to the alternative account for the minimal attachment effects is a comparison of how the pattern is changed when the sentences are encountered in context. Basically, for total gaze durations the non-minimal attachment sentences with a focussed appropriate antecedent lead to exactly the same pattern as the minimal attachment materials when in context. In other words, the context seems to override the minimal attachment effect for the focussed antecedent cases but not for the unfocussed antecedent ones, where readers behave as if the sentences were in isolation. A similar pattern of results is also found in the analysis of regressive eye-movements, where the non-focussed non-minimal attachment condition yields significantly more regressions from region 3 than either of the other two conditions which do not differ. Furthermore an almost identical picture emerges for the reduced relative sentences also tested in this same experiment.

It would seem therefore that the preference for simple syntactic structure is not necessarily the full explanation of why readers become garden pathed in sentences such as (3) and (5). It could rather come from the referential processing problem of encountering post-nominals in the absence of an appropriate discourse context. However, this alternative explanation proves ultimately wrong in an interesting way and the linguistic explanation, as we shall see, turns out to hold water.

The results which I have discussed so far only reflect the total time readers gaze at each of the critical regions and so may disguise subtle immediate processing effects. We can uncover this by simply plotting the initial gaze durations associated with each region before the eye moves on or regresses back to another region. This data is shown in a comparable way in Figure 2. Here first we can see the immediate effects of reading the sentences in isolation, which are shown in the curves with heavier lines. On first pass reading, the effects of minimal attachment only show in fixations in the disambiguating region and beyond, reflecting the fact that the sentences are of course identical up to this point. But again the really interesting result comes from the comparison between this pattern for MA and NMA (sentences of type 2 versus 3) where on initial fixation the NMA sentences in context behave basically like the sentence in isolation, that is irrespective of the focussing manipulation readers take reliably longer fixating the disambiguating region than they do with the MA sentence.

Figure 2.



First pass fixation times for the four regions in the critical sentences, when read in isolation and in either the Focus or the Non-Focus conditons.

To understand this apparently conflicting set of results, we have to suppose that the syntactic structural preference is still present even when the sentences are encountered in appropriate contexts. However, the results also demonstrate how the reader can recover almost immediately from the initial misinterpretation that this sometimes causes, just so long as the context is supportive in a way that is consistent with the limited focussing constraint. So this pattern of results illustrates quite clearly just how complicated the relation can be between the structure of the language and the way in which we as its fallible human users go about understanding it. Such a conclusion is very far from the simple view that structure dominates the interpretation process. While this may be true for the first few hundred milliseconds, other more context-dependent considerations come into play almost immediately.

My second case study relates to a somewhat different issue which concerns the role of definiteness in triggering special processes of accommodation of a referent into the current discourse model. As a background to the discussion I first want to consider some general findings about how contexts may extend the domain of potential

discourse referents and so aid the interpretation of noun-phrases. I will then turn to the question of the extent to which this process is actually triggered by the structural information in the definite noun-phrase.

4. Focussing constraints and interpreting definite reference

In the standard linguistic literature on reference the paradigm discourse pattern is taken to be one where a discourse referent is introduced in an indefinite description, and then subsequently referred to with a definite (e.g. Heim, 1982). Thus examples such as (9-10) are taken to reflect the norm.

(9) A man was walking down the street in a dream.
(10) The man tripped over his shoe-lace and fell.

However, as Fraurud (1990) has shown this pattern of indefinite introduction and subsequent definite anaphoric reference is in fact relatively rare in actual written discourse. In particular, the normal use of the definite NP is to introduce something which can be readily accommodated into the context. So on a clear night it is quite normal to talk of *the moon* or *the sky* or *the stars*, and even when indefinites are used they rarely introduce referents which will be subsequently referred to with a definite.

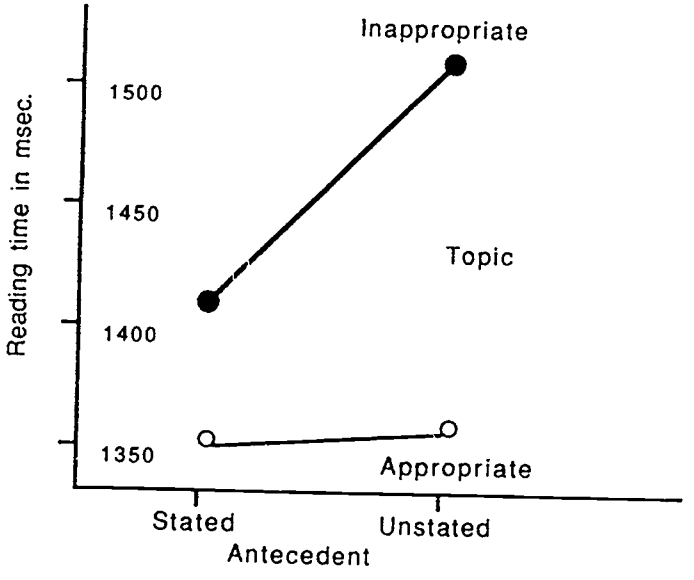
This kind of observation led Garrod and Sanford (1981, 1983) to design two experiments aimed at uncovering some of the contextual factors which might lead to the satisfactory accommodation of definite references. The basic rationale behind the studies was to set up either good accommodating contexts or poor ones, and then contrast situations where the referent had been explicitly introduced into the context with those where it was left unmentioned. So, for instance, in one experiment (Garrod and Sanford, 1983) the good contexts might include a passage under the title 'A day in court' which invokes a scenario of a court case affording reference to such characters as *lawyers, a judge, a defendant* and the like who play well known roles in this particular situation. This would be contrasted with a similar passage but under the title 'Telling a lie' which would not normally evoke the court case scenario (see Figure 3 for example materials). The critical contrast was then made by having in each passage either an explicitly mentioned antecedent lawyer or not and the measure taken was to record the overall reading time for a subsequent target sentence containing a definite reference to *the lawyer*. The pattern of results is shown in Figure 3. As expected, we found that readers were just as quick to accommodate a first reference to the lawyer in cases with no antecedent mention as they were in cases where an antecedent had been introduced, but only when the passage clearly evoked an appropriate scenario.

Figure 3.

Garrod & Sanford (1983)

	Appropriate Topic Passage
Title:	*In court*
Context S.	Fred was being questioned *(by a lawyer)*
Filler S.	He had been accused of murder
Target S.	*The lawyer* was trying to prove his innocence

	Inappropriate Topic Passage
Title:	*Telling a lie*
Context S.	Fred was being questrioned *(by a lawyer)*
Filler S.	He couldn't tell the truth
Target S.	*The lawyer* was trying to prove his innocence



So this study suggested that the domain of potential reference for definite NPs could be extended as a result of the readers general knowledge of the situation evoked. A further related experiment suggested that the extended domain of reference was however limited, or, in relation to the discussion in the introduction, subject to the limited focussing constraint. This study (Garrod and Sanford, 1981) used verbs which restrict their implied instruments, such as the verb *drive* which restricts its instrument to being some form of vehicle. Thus contrasting context passages were developed, as in (8-9) below, for a subsequent target sentence containing a reference to the instrument (10).

(8) Keith *drove* to London.
(9) Keith *took* his car to London.
(10) *The car* kept overheating.

As in the previous study, it was expected that readers would encounter no special problem in interpreting the antecedentless definite description in (10) following (8) as opposed to (9). In fact this result was observed in the reading times. However, there was also an additional manipulation in which the reference to the car in (10) was replaced with a reference to a part of the car, namely *the engine*, and with materials like this readers did take much longer interpreting the sentence in the absence of an explicitly mentioned antecedent.

The second study therefore suggests two things, first that having a context which introduces restricted antecedent roles such as *the vehicle used to drive* does not have quite the same effect as contexts which explicitly introduce the referent itself. In other words, our interpretation of the text does represent in a rather special way those things that the writer has chosen to focus on explicitly as opposed to merely imply. The second thing is that the context sets up a rather strict restriction on the role, that is only references which exactly fulfil the restrictions of the role seem to be accommodated. Thus knowing that someone is *driving* somewhere is sufficient to enable us to establish what role a car would be playing but not to establish the role of the *engine* in the car.

However, in the context of the present discussion it could be argued that these results may have little to do with the linguistic structure of the text. It is generally accepted that contexts may serve the function of priming a reader, so enabling faster word recognition irrespective of the syntactic environment. In other words, it could be that reading about a court case or someone taking a drive may be sufficient to prime any analysis of words such as *lawyer* in the former case or *car* in the latter. The trouble is that overall reading time for the critical sentences will among other things reflect just such generalised priming of the words in the sentence. Clearly, if limited

focussing on the potential roles afforded by a context is playing a proper part in the interpretation of definite descriptions, it must be shown that the effects are especially associated with understanding definite references.

For this reason Garrod, O'Brien, Morris and Rayner (1990) designed an eye-tracking study to investigate the immediate effects of contextual restriction on definite as opposed to indefinite descriptions. The materials were somewhat different from those used in Garrod and Sanford (1981) in that they always contained a potential antecedent for the critical NP. but in half the cases it did not lexically match the subsequent reference. For instance, in the example shown in Table 2 with a reference to *knife* the text antecedent could either be introduced as *weapon* (non-matching) or *knife* (matching). However, in half the cases it was the instrument to a restricting verb (*stab*) and in the other half a non-restricting verb (*assault*). So in line with the previous study we might expect that in a restricting context the reader should have no trouble accommodating the reference to *knife* irrespective of the presence of a lexically matching antecedent, but encounter problems when neither the antecedent matched nor the verb was restricting. As a final manipulation, the syntactic environment of the second mention was manipulated, so *knife* could either occur as part of a definite or indefinite description. This final manipulation therefore gives a direct test of the linguistic input to any process which takes account of the contextual restriction. If these results only reflect a rather generalised priming effect, they should be insensitive to the syntactic environment of the target item; if they reflect the operation of a special 'reference' analysis process associated with definiteness, they should be sensitive.

Table 2.

Materials in Garrod, O'Brien, Morris and Rayner (1990)

All the mugger wanted was to steal the woman's money. But when she screamed, he **[stabbed] [assaulted]** her with his **(knife/weapon)** in an attempt to quieten her down. He looked to see if anyone had seen him. He threw **{the} {a}** knife into the bushes , took her money, and ran away.

Factors manipulated:

(1) Restricting versus non-restricting context for the antecedent. (i.e. **stabbed v. assaulted**)

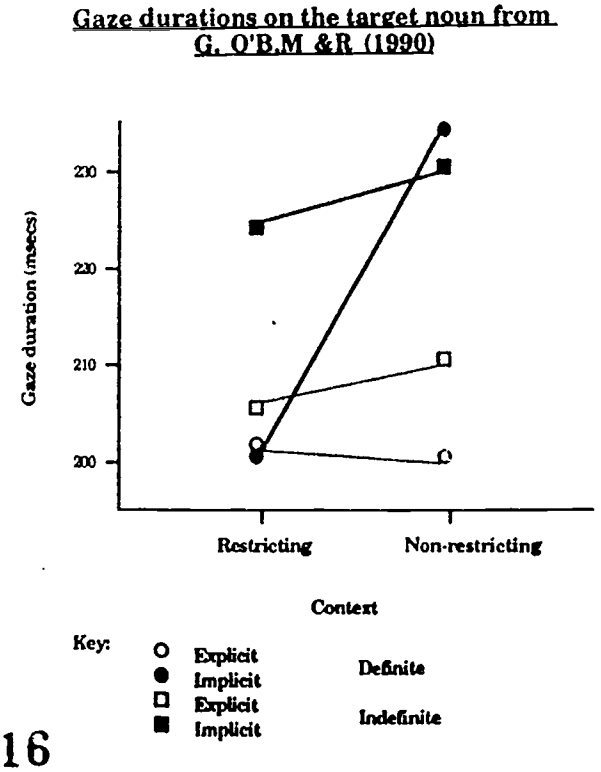
(2) Explicitly matching antecedent for the target noun knife. (i.e. **knife v. weapon**)

(3) Target in definite or indefinite NP. (i.e. **a--- v the-----**)

The test comes from looking at the average time readers fixate the critical noun (e.g. *knife*) under all of these conditions, and the results are shown in Figure 4. Considering first the non-restricting context it is apparent that the definiteness contrast has no effect on fixation duration. If a knife has been introduced into the context and then the term knife is encountered subsequently in either a definite or indefinite NP, there seems to be a generalised priming effect for reading the second mention. However, the evidence from the restricting context condition does support the operation of a special reference analysis process aimed at accommodating the reference into the context. In this situation having a restricting context alone is quite sufficient for the reader to immediately accommodate the definite reference (i.e. there is absolutely no difference in fixations as a function of lexical matching with the antecedent). However, when the second mention is in an indefinite NP, the contextual restriction gives no advantage to reading the noun.

So the results from this study go some way towards delimiting the contribution of the general psychological competences such as generalised contextual priming to the structure-driven processing of language. Clearly there is a general effect of priming operating here associated with repeating a word, but that effect is not sufficient to account for the more linguistically driven process of accommodating a definite reference into the context.

Figure 4.



5. Conclusion

This paper started out with some rather general considerations about the problem of reconciling psychological accounts of discourse processing with linguistic accounts of the structure of the language. From the outset, it was recognised that there are a number of psychological processing constraints that are very much at variance with how the linguist has tended to approach the task of describing linguistic structure. The first of these I dubbed the 'immediacy constraint', which puts a premium on incremental left to right interpretation. The second less well defined constraint was what I dubbed the 'limited focussing constraint', which imposes limits on what can be considered relevant background information which the processor may have ready access to.

The two case studies which I briefly described have some bearing on both of these constraints. In the first one, parsing can be seen as a problem of how to reconcile partial structural ambiguity with immediacy in processing. The human parsing solution that is suggested by the data reported here is certainly ingenious. It seems that the system is, in the first instance, responsive to structural features of the input, opting to follow the simplest structural alternative. However, as we also observed, when such sentences are encountered in appropriate contexts, the system seems to be capable of recovering from the garden path almost immediately, but only within the limits of focussing constraints which affect the reader's ability to recover the necessary contextal information. So both immediacy and limited focussing play an important role in parsing.

The second case study explored the role of syntactic marking of the noun-phrase in the immediate processing of definite descriptions. Here the central issue was the extent to which a general psychological competence associated with 'priming' of the sort underlying many cognitive activities might account for accommodation of definite references. This is of some importance in the light of recent demonstrations that 'connectionists' non-rule based association systems may be able to account for much of human language processing. If this were the case, then such things as resolving reference might be processes which reflect a general psychological competence for establishing associations between related events. The alternative is that it is a rule-governed process conditioned by the structural form of the input. In the syntactic environment of a definite noun-phrase the noun should be accommodated into the context in a way quite different from when in an indefinite syntactic environment. The overall conclusion from this set of studies was that while lexical priming was in evidence it could not account for the subtler effects of

contextual restriction which only come to light when processing definite noun-phrases.

What both case studies show is how it is possible to reconcile the psychological with the linguistic in accounts of language processing. But at the same time we have to be sensitive to the fact that any efficient process has to satisfy a number of constraints both psychological and linguistic, and *a priori* there is no good reason for imagining that any of these constraints will dominate.

Note 1. This is the solution adopted in computational linguistics in the use of chart parsers.

References

Fraurud, K. (1990) Definiteness and the processing of NPs in natural discourse. *Journal of Semantics* 7, 4:395-435.

Frazier, L. and Rayner, K. (1982) Making and correcting errors during sentence comprehension: Eye-movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology, 14*: 178-210.

Frazier, L. (1987) Sentence processing: A tutorial review. In M. Coltheart (ed.). *Attention and Performance XII: The Psychology of Reading.* Hillsdale, N.J. LEA : 544-586.

Garrod, S. and Sanford, A.J. (1981) Bridging inferences in the extended domain of reference. In J. Long and A. Baddeley (eds.). *Attention and Performance IX.* Hillsdale, N.J. LEA: 331-346.

- (1983) Topic dependent effects in language processing. In G.B. Flores d'Arcais and R. Jarvella (eds.). *The Process of Language Understanding.* Chichester, Wiley: 271-295.

Garrod, S., O'Brien, E.J., Morris, R.K. and Rayner, K. (1990). Elaborative Inferencing as an Active or Passive Process. *Journal of Experimental Psychology: Learning, Memory and Cognition.* 16: 250-257.

Heim, I.R. (1982) The semantics of definite and indefinite NPs. PhD dissertation, Dept. of Linguistics, University of Massachusetts, Amherst, MA.

Marslen-Wilson, W.D. and Tyler, L.K. (1981) Central processes in speech understanding. *Philosophical Transactions of the Royal Society London B 295*: 317-332.

Rayner, K., Garrod, S. and Perfetti, C. (In press).

Rumelhart, D.E. and McClelland, J.L. (1986) On learning the past tenses of English verbs. In J.L. McClelland, D.E. Rumelhart, and the PDP Research Group (eds.). *Parallel distributed processing: Explorations in the Microstructure of Cognition, Vol 2. Psychological and Biological Models.* Cambridge, MIT Press: 216-271.

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