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What, When, and How?: Questions of Immediacy in Anaphoric Reference Resolution

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This paper considers the question of the immediacy of interpretation of anaphors. Two aspects of immediacy are considered: (1) immediacy in terms of the initiation of processes that might be considered as supporting resolution, and (2) immediacy in terms of achieving resolution as an outcome. The functional justification, and the logic of these aspects are considered. The bulk of the paper is a review of pertinent experimental evidence. On the basis of studies both on speech and reading comprehension, we argue that the evidence favours immediate initiation. However, it is argued that immediacy of outcome must take into account the variety of different forms of definite anaphora: proper names, full definite descriptions, and pronouns. Whereas there is good evidence for early resolution in the case of the first two, it does not hold for all cases of pronominal anaphora. Furthermore, evidence from a variety of stylistic phenomena indicate the need to disentangle carefully the semantic constraints introduced by all forms of description. We conclude that immediacy must be understood in the context of the component processes making up reference resolution in relation to interpreting the sentence as a whole.

INTRODUCTION

The purpose of this paper is to discuss the question of the immediacy of anaphor interpretation, and to evaluate some of the pertinent empirical evidence. This is part of the broader question of the extent to which processes of language understanding in general are immediate, and to what

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extent some processes might be deferred. There is a view known as the immediacy hypothesis that amounts to the proposal that each word of a discourse is interpreted as deeply as possible and as quickly as possible, i.e. as soon as it is encountered (Just & Carpenter, 1980). We shall use this position as a baseline for discussion. Let us begin by setting out some of the reasons why the question of immediacy has arisen at all.

**THE FUNCTIONAL JUSTIFICATION FOR IMMEDIACY**

At its broadest, the immediacy hypothesis concerns the interpretation of more than just anaphors. Indeed, Just and Carpenter (1980) hypothesise that each and every content word is interpreted to the “deepest possible level” as soon as it is encountered, even at the expense of making guesses that sometimes turn out to be wrong. In a similar vein, Marslen-Wilson and Tyler (1981) argue that for speech the on-line goal of the processor is to achieve a message-level interpretation of the signal as rapidly and as early as possible. The general debate about immediacy, therefore, concerns two basic issues: (1) how soon any process is initiated and carried out, and (2) the extent to which immediacy applies at all levels of processing.

The functional argument for immediate initiation and rapid completion of any linguistic process is at least twofold. In the first place, holding off interpretation until more information has been sampled will impose a concurrent memory load on the system as the signal is held over for subsequent consideration, and this should be avoided. Secondly, it will mean that any contextual benefit that might accrue from interpreting the earlier expression will not be available to help in interpreting the subsequent expressions in the sentence. It should be noted, that for this to be a strong argument, it must be assumed that in general context constrains in a forward direction rather than backward. Other, more subtle, functional arguments can be made in favour of immediacy in speech comprehension. In speech, the signal is transient and not under the listener’s control. Therefore, deferring a decision until more information has accrued imposes a processing debt to be redeemed at a later date when the signal may still be coming in and competing for attention. Ideally, the decision rate should be geared to that of the signal if the processor is to avoid the risk of falling behind the speaker, so to speak. In reading, this is not such a major consideration, as the reader can always choose to pause at any point. Thus, there would seem to be good *a priori* grounds for immediacy in language processing in general, which come from a requirement to synchronise the processing with the sampling.

The second part of the immediacy hypothesis concerns the question of doing the immediate processing as deeply as possible. The basic justifica-
tation here is that the main goal of the processing system should be to determine the significance of what is being said or written, and it would seem efficient to do this at the earliest possible time. However, justifying immediacy at the message level is more controversial. It may be more efficient overall to pull in a lot of evidence before being committed, thus saving time-consuming and confusing backtracking. So the functional argument can go either way. It really hinges on the question of whether at any level of processing forward contextual constraints tend to outweigh backward constraints in securing a final interpretation. In fact, even in the case of lexical identification in continuous speech, there is some evidence for the operation of subsequent context in the process, leading to delayed decisions at this level (Bard, Shillcock, & Altmann, 1988). This would suggest that the immediacy question in relation to anaphors is very much an empirical one, even if one takes for granted the assumption that the processing system as a whole has evolved to operate with optimal real-time efficiency.

Important though these general arguments might be, it is therefore at a more detailed level that the discussion proliferates and the opportunities for experimental examination lie. The present paper is concerned rather more specifically with immediacy in the context of anaphoric reference resolution. Such resolution is arguably a necessary part of building up a coherent mental representation of a discourse. Until anaphoric relations are fixed, other aspects of coherence establishment may be delayed; at the very least, anaphora is a good a priori candidate for immediacy. Yet nowhere is it clearer that the plausibility of immediacy is a function of the linguistic input. In this paper we concentrate on personal pronoun anaphors (he, she), it, and fuller nounphrases. To illustrate some of the issues, let us first consider personal pronouns. In (1), it is clear that we cannot understand the sentence fully until we recognise that it is John who crossed the road, and such a resolution could take place as soon as the pronoun is encountered, at point a:

1. John saw Mary, and he$_a$ crossed the road$_b$.

Of course, in many cases, anaphor resolution is apparently not possible until information after a pronoun has been utilised, as in (2):

2. Mary gave Sue some money because she$_a$ was hard up$_b$.

In the first case, the fact that there is only one matching antecedent allows a decision to be made regarding the antecedent at point a in sentence (1), whereas in sentence (2), the decision has to be deferred to point b. The advantage of an early decision, triggered at point a in sentence (1), is that the information that follows could be related to the correct individual as soon as it is encountered, whereas the delay necessitated by the ambiguity
of antecedent in (2) means that the information after a has to be used to determine the referent of she, and then related to that referent. If there are many more unambiguous cases than ambiguous ones in language use, then an early assignment (immediacy) processing configuration may be preferable over deferral. It is of course true that the referent at point a in example (2) cannot be logically determined, but certain default biases may be used to force a decision. For instance, there is evidence that in at least some situations, naturally occurring examples of ambiguity can be settled on the basis of such things as sentence topic. An example is the observation made by Broadbent (1973) with the following, taken from a manual:

3. The feedpipe lubricates the chain, and it should be adjusted to leave a gap half an inch between itself and the sprocket.

In this study, it was established that most people took the intended referent of it to be the feedpipe, and not the chain, although the subjects were quite ignorant of what any of these things were.

Immediacy is interesting because it is related to what the understander takes to be sufficient evidence to resolve anaphoric reference. The examples discussed above are just a few of many, but illustrate some of the boundaries of the problem. Even with logically ambiguous reference, heuristic principles may be used to produce an early interpretation, but there will always be a risk of error. The importance of the error in terms of the overall efficiency of the system will depend upon how often the heuristic principle runs foul of a real example. If producers on the whole do not produce utterances that require delay, then the system does not need to delay. Of course, our example concerns the personal pronouns he and she. With the pronoun "it", the opportunities for multiple interpretations are even greater, as shown in (4):


Here, It could refer to the event, the market, or even be non-referential (It was a lovely day for an outing). So when we turn our attention to this pronoun, deferred processing seems a lot more sensible. In contrast, fuller nounphrases are seldom ambiguous at the point of encountering them:

5. Mrs Thatcher discussed the modification of Britain's Universities with Mrs Currie. The prime minister . . .

With fuller nounphrases, immediacy of anaphor resolution seems sensible. Therefore, if the system is optimally tuned to the constraints of real-time efficiency, the answer to the immediacy question may well depend upon the type of phrase or word in question.
THEORIES OF PROCESSING, AND IMMEDIACY

In the discussion so far, we have taken the distinction between immediate vs deferred interpretation as straightforward, but as Bierwisch (1983) reminds us, giving a precise characterisation of immediacy is problematic. It is a truism that all processes take time, and so it is necessary to discriminate between the onset of processes and the point of their completion. This is complicating for any discussion of immediacy, because one must be careful to distinguish between experimental evidence favouring an immediate onset of processes supporting reference resolution, and evidence showing when resolution is completed. The idea of immediate initiation seems relatively simple: One can imagine some sort of ballistic process initiated as soon as the right trigger conditions are met. In the case of anaphora, we might hold that simple definite nounphrases should be such a trigger condition. Therefore, as soon as the processor determines that such a nounphrase is present, procedures to discover reference should be initiated. Hence, any definite description should be enough to trigger the process on the strictest version of the immediacy hypothesis. With complex descriptions containing restrictive relative clauses, for instance, the first possible nounphrase should result in some aspect of the resolution process being initiated, even if the rest of the clause is required to provide the necessary individuating information. With definite pronouns, processes should be initiated as soon as the system detects the presence of the pronoun. Operationally, therefore, immediacy of anaphoric resolution depends upon activity starting as soon as a definite nounphrase or pronoun is detected.

To make a claim about immediate completion of reference resolution is much more complex, both conceptually and experimentally. For resolution to have occurred, an anaphoric (semantic) relationship must have been computed, and this will take processing time. A demonstration of immediacy at this level would therefore depend upon demonstrating both rapid completion of the process, and that no other significant operations had taken place on subsequent input in the meantime. A strong version of this is the claim by Just and Carpenter (1980) that eye fixations are maintained until the item has been processed to the deepest possible level. A weaker, and equally interesting view, would be that completion takes place rapidly, even when there are arguable opportunities for deferral. This version underlies accounts of processing that assume temporary assignment with the possibility of later revision.

Theories of completion are inevitably more complex than accounts of initiation, and are discussed more thoroughly later in this paper. Our first concern is with evidence for immediate initiation of process, and with the
time course of various processes once initiated. For each technique discussed, we shall examine just what kind of processes are being detected.

EVIDENCE FOR IMMEDIATE PROCESSES IN REFERENCE RESOLUTION

A wide variety of methods have been used to probe the time course of processes associated with reference resolution. Often, these have been treated as though they answered questions about specific versions of the immediacy hypothesis, when in fact they are not sufficient to do so. However, there is a great deal of evidence supporting early (immediate) triggering of processes that are arguably pertinent to reference resolution. We begin with evidence from processing speech.

Speech

As we shall see, there are many experiments that bear on the immediacy hypothesis in reading. In speech comprehension the evidence is sparser, but what evidence there is does tend to give general support for immediacy in all the main forms of definite anaphor.

The speech experiments that we consider have all employed some variant of the cross-modal priming paradigm (Swinney, 1979), where a written word is presented for lexical decision (or naming) at some critical point in the speech stream. The first was reported by Shillcock (1982), using materials like (6):

6. The teacher_a did not board the train for the_b simple reason that it/he_c was not going to the south of England.

In this study, the written target word related to a potential antecedent for a pronoun in the speech. Consider the potential target contrast school vs street. Either probe could be presented before the pronoun had been encountered (at b) or immediately after (at c). So in this case, the test of immediacy comes from a comparison of the pre- to post-presentation priming effect for the lexical decision, where the priming effect is measured in terms of the difference in lexical decision time between school and street. Any priming difference in favour of the appropriate antecedent should then indirectly reflect resolution of the pronoun at that point.

Shillcock's (1982) results did give partial support for this in that he was able to report a pre- to post-presentation priming difference, but only to the extent that the pronoun which did not identify the probed antecedent resulted in a reduced effect over the pre-presentation priming level. Presumably, in this case, the probed antecedent was sufficiently in focus at point b (prior to encountering the pronoun) to produce a priming effect,
but then was defocused by the presence of a pronoun identifying a different antecedent. Therefore, although it would have been more satisfactory if the antecedent had not already been primed before encountering the pronoun and a positive advantage could have been detected, this result is certainly consistent with early resolution. However, as we shall stress repeatedly, priming results of this kind do not necessarily evidence completion of referential resolution. They simply indicate that the pronoun has in some way immediately activated the antecedent or in this case deactivated a non-antecedent. (A similar observation was made by Gernsbacher, 1989, using word-by-word visual presentation.) What type of semantic relationship has been computed to hold between anaphor and antecedent (if any) is not in any way addressed with this procedure, let alone when such a relationship is established. The remaining speech comprehension experiments are somewhat clearer on this point.

Tyler and Marslen-Wilson (1982) reported a more extensive study using a slightly different form of cross-modal priming as an index of resolution. Their experiment is best discussed in relation to an example of the materials and procedure. The subject was required to name the visually presented probe him or her following one of the auditorily presented fragments (a, b, or c) shown below:

As Philip was walking back from the shop, he saw an old woman trip and fall flat on her face. She seemed to be unable to get up again.

a. Philip ran towards . . .

b. He ran towards . . .

c. Running towards . . .

The probes were chosen so that one (e.g. her) was consistent with the contextual interpretation of the fragment, and the other (e.g. him) inconsistent. They reasoned that any advantage in terms of naming latency for contextually appropriate probes could only arise if the subject of the clause had been established at that point and hence the anaphor resolved. In fact, the results indicated that in all conditions such an advantage occurred, even though the distinction was somewhat sharper for both the proper name and pronoun anaphors than the zero anaphor with the verb phrase alone. Therefore, this result gives strong support for the resolution of both the anaphoric pronoun and proper name by the time the verb has been encountered. Even more striking is the numerically smaller result they found in favour of immediate resolution of the zero anaphors (condition c).

This experiment is more informative than Shillcock's (1982) in a number of ways. It demonstrates a broad similarity of effect for all forms of anaphora studied and it uses a technique that addresses more clearly the nature of the anaphoric relation which is having the effect. In order to
impose such a constraint on the continuations (e.g. him or her), the subject of the clause must have been established to some degree (i.e. at least to the extent that it accounts for all antecedents of that gender in the context and this requires computing a semantic relation between anaphor and antecedent). However, it is worth noting that the probe is downstream of the critical anaphor in coming after the main verb, and it may well be that the verb is the functionally critical point for triggering assignment of subject pronouns. Therefore, does this study clearly favour some version of immediate completion over the weaker immediacy of activation?

A more recent follow-up by Marslen-Wilson, Tyler, and Koster (reported in Marslen-Wilson & Tyler, 1988) throws some doubt on an immediate completion explanation of the result. They used the same basic procedure but within a factorial design including a number of additional manipulations. The targeted antecedent could either be a thematic subject of the discourse or not (see below for a fuller discussion of the importance of this variable in the context of the reading experiments). The pronoun could either match the antecedent in gender or not, and finally the verb could be congruent, incongruent, or neutral with respect to the context and the targeted antecedent. Examples of materials in all conditions are shown below:

1. **Thematic subject antecedent with congruent verb:**
   After the surgeon had examined the 12-year-old girl with the badly broken leg, he decided he would have to take immediate action. He'd had a lot of experience with serious injuries. He knew what he had to do next.
   a. He quickly injected . . .
   b. She quickly injected . . .
   c. Quickly injecting . . .

2. **Thematic subject antecedent with neutral verb:**
   As Bill was buying popcorn at the movies, he saw an old girlfriend get in line for a ticket. He had arrived at the movies especially early. He wanted to be sure of getting a good seat.
   a. He waved at . . .
   b. She waved at . . .
   c. Waving at . . .

3. **Thematic subject with opposing verb bias:**
   Mary lost hope of winning the race to the ocean when she heard Andrew's footsteps approaching her from behind. The deep sand was slowing her down. She had trouble keeping her balance.
   a. She overtook . . .
   b. He overtook . . .
   c. Overtaking . . .
The factorial design allowed the experimenters to establish both the role of the different factors in determining the assignment after encountering the verb, as well as the interactions between them. In the first place, the results indicated that each of the factors alone was sufficient to determine resolution at this point. Therefore, for instance, in condition 2b there was a naming effect in favour of the antecedent matching the gender of the pronoun, going against the thematic subject bias but in the absence of a constraining verb. In condition 2c, the effect favoured assignment of the subject to the antecedent which was the thematic subject of the discourse, so confirming the importance of this factor when not in competition with either gender (because there is no pronoun here) or verb congruency (because the verb is neutral). Similarly, they found strong effects of verb congruency in all conditions when it did not go against pronoun gender. But the most interesting results come from looking at what happens when these various factors are pitted against each other. In particular, pitting verb congruency against gender seems to produce a dramatic effect. Hence, in the cases where the verb goes against the gender of the pronoun (conditions 1b and 3a), the average effect in favour of the gender matched assignment is only 15 msec, compared to an average effect of 60 msec when the two factors converge (e.g. conditions 1a and 3b).

Altogether, these results seem to be more consistent with a model of immediacy in which, as relevant information is encountered, it has an immediate and cumulative effect on interpretation, rather than one in which the earliest evidence results in a full categorical assignment. Clearly, in the absence of contrary evidence, the system prefers to go along with the first piece of evidence available, in this case thematic subjecheid or gender, but is nevertheless immediately capable of taking into account subsequent evidence as soon as it is encountered, as in the case of a contextually biasing verb. Thus at any point in the process, the system can operate with some weighted balance of accumulated evidence in favour of one assignment or another. Although not conclusive, this would seem to favour the immediate accumulation of evidence version of the process as opposed to a model of serial revision of categorical assignments.

Written Discourse

The presentation of written discourse is harder to tie to time than is speech, and so correspondingly more indirect and off-line measures have been used. A notable exception is the use of eye-tracking techniques, which represent the closest physical coupling of the reader to the text.

Self-paced Reading Time. With this method, materials are presented either a sentence, a clause, a phrase, or even a word at a time, in response to the subject pressing a button to see the “next piece of text”. With the
whole-sentence version, such a task has the advantage of being easy for the subject to do and requires little practice. But it has the disadvantage of being a rather crude instrument, in that the locus of an effect can only be inferred. While it has been used to make claims about factors influencing the ease of anaphor resolution, in the main these claims are being inferred from the ease (speed) with which sentences containing anaphors are read following sentences in which antecedents are manipulated.

Among the results pertinent to the immediacy question are those related to focus and thematic subject. It is widely argued that only a subset of conceptualisations resulting from discourse is available in attentional focus, a kind of working memory containing representations of currently important discourse entities. Focus can be understood in terms of the ease of accessibility of potential antecedents and control of inference patterns (see, for example, Grosz, 1977; Hudson, Tannenhaus, & Dell, 1986; Sanford & Garrod, 1981). Thus it will be easier to access representations which are in focus than those which are in longer-term memory, and this has implications for ease of reference resolution. Pronoun reference is demonstrably sensitive to focus. Thus Anderson, Garrod, & Sanford (1983) showed that pronominal references to characters which depend upon being situated in a scene are more difficult to process when that scene is cued as completed. (An example of dependence is that a waiter is dependent on a restaurant scene.) However, main characters, not dependent upon a particular scene, can easily be referred to by a pronoun after a change from the scene in which they have just appeared.

Hudson et al. (1986) manipulated reference to either the agent or patient of active sentences, and showed a processing preference for pronouns to be associated with agents (the “centred” target, in their terminology; cf. Grosz & Sidner, 1985). One contrast was between (7') and (7'') as continuations of (7):

7. Jack apologised profusely to Josh.

7'. He had been rude to Josh yesterday. (Centred target)

7''. He had been offended by Jack's comment. (Non-centred target)

They observed that reading times for centred targets were faster than those for non-centred targets, and suggested that “He” is immediately interpreted as Jack in both cases, so that in the non-centred case, reassignment would have to occur. Of course, these results do not demand an assumption of a completed categorical process; they are equally consistent with continuous evidence evaluation at a sub-threshold level. But they strongly suggest an immediate “attachment” of the pronoun to the agent. In a further experiment, similar materials were presented for self-paced reading on a clause-by-clause basis, with the second clause of the second sentence being the locus of disambiguation of the pronominal reference.
Reading times for the second clause were longest when this indicated that the pronoun in the first clause referred to a non-centred antecedent. The different roles that antecedents play in the discourse also influence reading times. For example, in simple narratives, with pronouns as anaphors, reading times to sentences containing references to the main character are faster than those for sentences containing references to secondary characters (Anderson et al., 1983). Sanford, Moar, and Garrod (1988) found that sentences containing pronominal references to characters introduced through proper names (e.g. Bill) were read faster than those referring to characters introduced through role descriptions (e.g. the waitress). This at least suggests that main characters—signalled through agency, dominant role, or proper name—may influence the speed with which assignments are made, and probably the bias in any initial pattern of activity leading to eventual resolution. This is consistent with the findings of Marslen-Wilson et al. (1982) on the importance of thematic subjeothood in the speech studies. We shall return to this point shortly.

Reading time experiments have also been useful in highlighting processing differences between nounphrase and pronominal anaphors. Studies of production in naturalistic settings suggest that nounphrases are used to reintroduce individuals which have slipped from focus, whereas pronouns are used to maintain reference to focused individuals (e.g. Marslen-Wilson, Levy, & Tyler, 1982). Hudson et al. (1986) substituted proper names for pronouns in examples like (7), and found no effect of centring. Sanford et al. (1988) substituted repeat nounphrases or proper names in their experiment, and found that there was no longer a differential effect of name/role antecedent. Taken together, the pattern of observations shows pronominal reference to be sensitive to theme and focus effects, which are top-down system states. Fuller nounphrases are not so sensitive, and appear to override top-down guidance in the resolution process. This will be elaborated further. But the emerging picture is one in which immediacy and type of process is likely to be dependent jointly on focus state and incoming description type, a conclusion that is also consistent with the findings from the speech experiments cited above.

**Priming Studies.** Priming has been used as an index of the immediacy of resolution by a number of researchers. In general, the technique relies upon the subject judging whether or not a word has been presented in a text, carrying out a lexical decision task on a word, or reading a word out loud. If a facilitation can be obtained for a word either related to or the same as an “antecedent” when an anaphor has been presented, then this constitutes evidence for an active process, as discussed in the section on speech. McKoon and Ratcliff (1980; in press) have used recognition memory for single words in relation to nounphrase anaphors, as shown
A burglar surveyed the garage set back from the street.
Several bottles of milk were piled at the curb.
The banker and her husband were on vacation.
The criminal slipped away from the streetlamp.

*The criminal* and *a burglar* are coreferential, and the argument is that if this relationship is established during reading the final sentence, then recognition of the test word *burglar*, presented at the end of the sentence, should be facilitated relative to a suitable control, such as replacing *the criminal* with *a cat*. They found that recognition of *burglar* was facilitated by the reference to *the criminal* rather than *a cat*. There was no difference for the control word *bottles* when presented in each condition. The suggestion is, therefore, that the anaphor activates some representation of the antecedent *a burglar*. The activation also seems to spread through a representation of the original action in which *a burglar* was involved (surveying the garage), because additional tests showed that *garage* was also primed by the reference to *the criminal*. Therefore, there is evidence for integration supporting anaphoric resolution with full nounphrase anaphors, at least by the end of the sentence in which the anaphors appear.

Although McKoon and Ratcliff's (1980) study did not pinpoint the time course of the priming effect, a subsequent study by Dell, McKoon, and Ratcliff (1983) did. Using a modification of the procedure described above, the test word was displayed in positions after every word of the final sentences of the materials. The words were presented at a rate of one per 250 msec, at a fixed rate. Priming for the referent of the noun of the anaphor reached its maximum (asymptotic) value only 250 msec after the appearance of the anaphor, indicating a fast activation process. The companion words from the same proposition reached a peak on a similar time-scale, indicating an early spread of activation over the representation of the action in which the protagonist was involved.

There are several problems with this study, one of which is that at best the results only show that a word conceptually related to the referent serves to activate the referent. If *the criminal* activated the antecedent *burglar*, we might suppose that it is because the expression is an anaphor that the priming pattern obtained, but it might be because the word "criminal", rather than the anaphor *the criminal*, is facilitating. This issue can be addressed by comparing non-anaphoric nounphrases containing the critical word as a control. This was done by O'Brien, Duffy, and Myers (1986), who compared *the stalled vehicle* as an anaphor of *the bus* (which had come to a halt) with *a police vehicle*, which is non-anaphoric, but semantically related in that it contains the term *vehicle*. They observed that
even the non-anaphoric expression resulted in priming, though not quite to the same extent as the anaphoric case.

Whereas this indicates that some priming might be due to pre-existing lexical associations, it does not explain why other elements of the proposition containing the antecedent are also primed. Indeed, this data suggests that it is the entire antecedent conceptualisation that is being facilitated as soon as the anaphor is encountered. Such a finding indicates that the resolution process is well advanced immediately after encountering the noun phrase anaphor and before encountering any other information.

Another problem is highlighted by O'Brien et al. (1986): Fast recognition times could reflect either semantic priming or backward integration effects. Backward integration results from a probe being compatible with antecedent material and is known to influence priming effects with lexical decision tasks (e.g. Seidenberg, Waters, Sanders, & Langer, 1984). O'Brien et al. attempted to control for this possibility by using a task in which subjects had to name probes rather than perform a recognition check, on the assumption that naming is not sensitive to backward integration (Seidenberg et al., 1984). When this was done, the non-anaphoric condition did not show any evidence of a priming effect, whereas the anaphoric condition did. On the strength of this, it could be argued that naming is better than lexical decision as an index of an inferential process (Keenan et al., in press). Regardless of this, Dell et al.'s (1983) data on whole conceptualisation priming indicates an increased sensitivity, consistent with resolution processes.

Stevenson (1986) studied pronoun anaphora by using phrase-by-phrase presentation, coupled with recognition of whether or not a test word had been previously presented. An example of the material is as follows:

John apologised to Anne at the end of the class because he regretted having caused so much trouble. \( \{ \text{early} \} \) \( \{ \text{late} \} \)

On a probe trial, the word John or Anne was presented instead of one of the phrases. In the early condition, it followed the second phrase, whereas in the late condition it followed the third phrase. Subjects had to decide whether the probe words had been presented in the text (made possible by various filler conditions). Stevenson (1986) found that recognition times to test words that were antecedents were shorter than times for non-antecedents, when compared with the early control. This result was taken by Stevenson as indicating that "selection of a unique antecedent" has taken place by the time one word after the pronoun has been read. When gender cues are eliminated by making the two protagonists the same sex, there is no reliable difference between recognition times for antecedent
and non-antecedent. This pattern would be anticipated, because resolution is not possible until the second clause has been read. These results imply that the pronoun immediately activates a representation of its antecedent if that antecedent is unique and of the same gender. It does not, however, mean that reference is "resolved" at that point, although this interpretation is given by Stevenson.

Taken together, data from priming studies of both nounphrase and pronominal anaphora suggest that some processes, which may support the establishment of anaphoric relations, are initiated early, as discussed in relation to the speech data. However, precisely what kind of processing is being revealed is at present somewhat contentious, and there is little to support or deny the claim that reference resolution goes through to completion on the basis of minimal disambiguating evidence. There is clearer evidence in the case of full nounphrases, but no strong evidence either way for pronouns in this respect. A recent study by Gernsbacher (1989) using word-by-word presentation in conjunction with recognition probe latency reinforces this position.

Explicit Assignment. In the case of pronouns where there is more than one possible antecedent, an explicit assignment task can be used in which the subject is required to press a particular button to indicate which assignment has been made. Because the subject's task depends upon making a choice of referent, there would appear to be no question of whether or not an assignment is actually made, although we shall be at pains to point out that the picture may not be so ideal as this would seem to suggest. This widely used task enables one to assess the utilisation of cues from a number of sources.

There is evidence from a variety of such experiments that the more cues there are supporting an interpretation, the faster the assignment can be made. For instance, a gender cue can be used to disambiguate a potential antecedent, so that in (8), the processor could determine the referent of the pronoun unambiguously by point a:

8. Steven blamed Jane because she, a spilled the coffee.

In contrast, the following case requires an analysis of the event before an unambiguous interpretation could be given:

9. Steven blamed Frank because he spilled the coffee.

Ehrlich (1980) showed that assignment times were shorter for examples like (8) than for (9), although when pragmatic information is consistent with a gender-driven resolution, the time to make that resolution is still reduced somewhat. Her principal conclusion was that gender cues, when available, are used to resolve reference (immediate resolution of some
sort), extra information playing a major role only if necessary. Therefore, in the absence of a gender cue, the assignment is inevitably slowed down. Similar observations and arguments have been made by Springston (1976).

One problem with the study is the length of the response times, which are longer even than reading times for complete sentences under self-paced conditions. This makes it difficult to use such data to evaluate whether any process supporting anaphor resolution is initiated as soon as the pronoun is encountered. However, it does suggest that evidence after the pronoun may enter into the final resolution process, even when the gender cues are sufficient to disambiguate the referent on the basis of the pronoun alone. This seems to suggest an ongoing evidence collection process, which takes into account available evidence as it appears.

There is other evidence to suggest that subsequent information will influence overt assignment times, even when such information is not strictly necessary. Thus Caramazza, Grober, Garvey, and Yates (1977) found an effect of subsequent pragmatic information even when gender cues were available to cue a unique assignment. Hirst and Brill (1980) and Stevenson and Vitkovitch (1986) obtained similar findings. For example, Stevenson and Vitkovitch compared assignment times for the four cases shown below:

Jane stood watching.
Henry jumped across a ravine
and (he) fell into the river.

Jane stood watching.
Henry jumped across a ravine
and (he) picked up some money.

The parentheses denote the option of ellipsis or pronoun. In the upper example, the second clause of the second sentence is a highly plausible continuation of the first clause. In the lower example, it is implausible. Stevenson and Vitkovitch (1986) showed that the time to decide that “he” refers to Henry was longer in the second than in the first case, although the pronoun is completely unambiguous on gender grounds. The investigators claimed that this showed the duration of the resolution process to be dependent upon the pragmatic information that followed the pronoun. Certainly, it is possible to make an assignment as soon as the pronoun is encountered, and this does not seem to have happened.

As with assignment studies in general, the latencies were very long, averaging 3.7 sec. Perhaps under other conditions, there would be less opportunity for pragmatics to intervene when gender cues suffice. In explicit judgement tasks, there may be time for pragmatic information to speed up a response that is based on an outcome already established, a
possibility that makes it difficult to relate the results to theory. So the evidence from direct assignment tells us little about immediacy, and gives little definitive information about late processes in resolution. Even worse, perhaps, the task itself forces explicit decisions to be made, while in more normal reading situations, it is even possible that anaphor resolution does not always take place anyway.

When we turn to the studies using eye-tracking techniques, the relationship between findings from overall reading time, explicit assignment studies, and measurements of fixation durations in the vicinity of a pronoun, do turn out to be complicated in just the way one might expect.

Eye-tracking Experiments. On the face of it, recording eye movements during reading should prove to be the most secure way of establishing the timing of anaphoric processing under conditions of normal reading. On the one hand, it is possible to tell precisely which bits of text are being fixated at a given moment and, on the other, the technique is not intrusive. If one can demonstrate that fixation durations on the critical anaphoric word or phrase are both a function of the difficulty of the resolution process and that any increase in duration does not spill over to subsequent fixations, then this should evidence on-line activity. Of course, any claim concerning resolution would depend upon an independent demonstration.

In reviewing the eye-tracking studies, the situation does not seem to be quite so straightforward. For one thing, the critical words to be fixated are often exceptionally short, as in the case of personal pronouns, and such words only attract direct fixations on relatively few occasions (roughly 60%). This makes it difficult to predict where the increased fixation duration should be occurring (for instance, is it on the pronoun itself or in part on the word preceding it, or even the word following?). The second problem, which may well arise from this lack of resolution, is that different experimenters have reported different results from apparently similar studies. Therefore, whereas some experimenters (e.g. Ehrlich & Rayner, 1983) have been able to detect reliable effects in the vicinity of pronouns, others have not (e.g. Carroll & Slowiaczek, 1987). Bearing these limitations in mind, we shall briefly mention some of the relevant studies.

The main eye-tracking experiments that have some bearing on the immediacy question have been directed at the resolution of pronouns, the first of which was by Ehrlich and Rayner (1983). In this experiment, they manipulated the textual distance between an unambiguous pronoun and its antecedent and recorded fixation durations in the vicinity of the pronoun. This revealed increased overall durations around the pronoun with increasing text distance. But as the antecedent became less accessible (i.e. with ever-increasing distance), so the fixation effects tended to migrate to words downstream of the pronoun itself. Therefore, Ehrlich and Rayner con-
cluded that the data only supported a weak version of immediacy, because the reader did not hold fixation on the pronoun until it had been fully resolved.

A further study by Vonk (1984; see also Vonk, 1985) highlights the complicated relationship between the different measurement methods. Vonk used materials similar to those of Ehrlich’s (1980) explicit resolution study (see sentences 8 and 9). But she compared the results in terms of (1) assignment (choice) latency for the antecedents of pronouns with or without a gender cue, (2) overall reading time for the critical second clause, and (3) fixation durations on the pronoun itself under the various conditions. The pattern was most enlightening. First, she replicated Ehrlich’s earlier result and found increased assignment latency for the antecedent when no gender cue was present, but she also demonstrated that there was no overall increase in reading time for the second clause when the subjects were simply required to read the sentence. Finally, she was able to show a clear eye-fixation effect on the pronoun. If the gender disambiguated the pronoun, subjects were more likely to fixate it (83 vs 60%), and when they did so they spent 50 msec longer on the pronoun than in the case where there was no gender cue. Therefore, this study both highlights the difficulty of interpreting the off-line assignment studies in terms of immediacy, and the way various cues such as gender can lead to immediate processing effects when informative.

*Spelling Error Detection.* A task suited to nounphrases as well as pronouns goes some way towards overcoming the problem that resolution is perhaps being forced in an unnatural way through the demand for explicit assignment, yet still requires something like assignment to have taken place. This technique is in some ways parallel to the task of Marslen-Wilson et al. (1982). Garrod and Sanford (1985) used materials like those shown in Table 1, which depict interactions between two characters—a main character and a secondary character. In the last line, either the main character (Elizabeth) or the secondary character (the lifeguard) is introduced. The verb that follows (jumped or sank) is predictable for one character, given his or her state or role, and is not predictable for the other (although it is logically possible). Therefore, the verb *sank* is predictable for Elizabeth, whereas *jumped* is not. Now if this predictability were detectable through the ease of processing the verb, at the time the verb was encountered, then it must mean that on encountering Elizabeth, the processor activates the data structure corresponding to what is known about Elizabeth, and this results in a bias on processing the verb. The same argument applies to the lifeguard.

Garrod and Sanford (1985) investigated any on-line effect of verb predictability by changing the crucial verbs to misspelled versions (e.g.
### TABLE 1
A Dangerous Incident at the Pool (after Garrod & Sanford, 1985)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elizabeth was a very inexperienced swimmer and wouldn’t have gone into the pool if the lifeguard hadn’t been nearby. But as soon as she was out of her depth she started to panic and wave her hands about in a frenzy.</td>
<td></td>
</tr>
<tr>
<td>a. Within seconds Elizabeth</td>
<td>jumped* into the pool</td>
</tr>
<tr>
<td>b. Within seconds the lifeguard</td>
<td></td>
</tr>
<tr>
<td>c. Within seconds Elizabeth</td>
<td>sank* beneath the surface</td>
</tr>
<tr>
<td>d. Within seconds the lifeguard</td>
<td></td>
</tr>
</tbody>
</table>

*Misspellings: jimped, senk.

*jumped was changed to jimped; sank to senk*. The subjects’ task was to read each passage a line at a time, and press a button as soon as a spelling error was detected. Error detection latencies were shorter for predictable verbs for both character types. By using fillers in which errors appeared at various positions in the sentence, it was possible to carry out control regression analyses of detection latency against position in the sentence. Such analyses indicated that the errors were being detected as soon as the word was read.

One interpretation of these results is that when the anaphor is encountered, the result is to bias lexical analysis in favour of verbs that are compatible with the state of the character to which the anaphor refers. This is a complex pattern of activation, equivalent to “resolving” an anaphor. Therefore, for proper names, and for nounphrases denoting characters, we would claim that there is early initiation of processes of activation, and that these processes are consistent with the establishment of reference-based significance.

A second study suggested that nounphrases may bring about fuller interpretation (or richer activation) than pronouns seem to. In this experiment, Garrod and Sanford (1985) used the error technique on the same materials but with he/she pronouns substituted for the repeat names or role descriptions. The pattern of results was the same for main characters: Predictable verbs were processed faster than unpredictable verbs. However, for secondary characters, this was not true. Indeed, there was marginal evidence for a bias in the opposite direction, with the unpredicted verbs being processed faster. These complex results can be interpreted as showing that when a pronoun is encountered, an immediate “bonding” occurs between the main character (thematic subject) and the pronoun, a strong top-down influence of theme. If the fit is good (in terms of gender), the system will be as though resolution has taken place, although an explicit relation has not
necessarily been computed. The verb predictability pattern, which goes with the main character under these circumstances, is appropriate. But if the fit is poor, this is discovered relatively late, and so there is still a verb bias towards the main character, albeit a smaller and presumably diminishing one. Indeed, Garrod and Sanford (1985) noted that some of the subjects worried that the pronouns might be “wrong” (e.g. he should be she, etc.). Thus the bottom-up impact of a pronoun is very weak with respect to thematic subject, whereas the bottom-up impact of a nounphrase or a proper name is strong, consistent with our earlier observations.

Of course, this study is not without problems. Reading rates for subjects were about twice as long as normal, at 2 words per sec, and the error detection requirement is of course intrusive. Nevertheless, the results show that immediate events can and do occur, and the pattern fits the observations which come from reading time measures.

**SUMMARY AND CONCLUSIONS FROM THE DIRECT MEASURE STUDIES**

As we have seen, there is now quite a body of experimental research on immediacy of processing for both pronoun and nounphrase anaphors. All of the evidence, with the possible exception of Ehrlich and Rayner’s (1983) eye-tracking study, is consistent with the immediate triggering of anaphoric processes for both pronouns and fuller descriptions. In the case of the fuller nounphrases, evidence is also strong for a rapid completion of the process, whose results feed into the interpretation of subsequent material in the sentence. In other words, there is no evidence to suggest that a full nounphrase ever receives delayed interpretation, or that any immediate interpretation can be overridden by subsequent context.

The situation with pronouns looks much more complicated. The problem is that pronoun resolution is apparently subject to a number of constraints apart from gender and number matching. Evidence both from speech and reading indicates the prior influence of antecedent focus, and the subsequent influences of verb congruency. Therefore, while all these factors, including number and gender, seem to have an immediate processing influence, the resolution may be open to revision, or even not fixed at all, until well downstream of the pronoun itself. This raises the question of whether a pronoun receives an immediate categorical interpretation at the earliest point, which may be subject to revision, or that the final categorical interpretation is only made after a lag to see whether more disambiguating evidence is going to become available (such as after a main verb, or by the end of a sentence). No direct evidence is available to test these hypotheses, but some indirect evidence from investigations of stylistic phenomena may have some bearing on the matter.
STYLISTIC PHENOMENA AND IMMEDIACY OF PROCESSING

Apart from attempts at relatively direct measurement (as discussed above), there is a variety of related anaphoric phenomena that need to be understood in terms of the immediacy of processes, and their completeness. These phenomena are manifest when discourse structures are used, which are commonly avoided by any writer with average sensitivity for the reader. As such, they constitute situations in which component processes are being inappropriately or inadequately combined for the task at hand. In other domains, garden-path and related phenomena are well-known parallels. The present examples all use stylistic rather than grammatical unacceptability as a measurable aspect of processing strain. They can be viewed as phenomena that should be explained within the context developed above, or as tools for further exploring immediacy effects.

Sanford, Garrod, Lucas, and Henderson (1984) studied a phenomenon which they termed “false bonding”, and which they relate to the issue of immediacy. The subjective impression (termed a sounds-like effect) emerges clearly in examples where a pronoun is used to refer to an intended referent that is merely implied, and where there is another entity in the antecedent sentence that matches the pronoun in number and gender:

10. Harry was sailing to Ireland. It sank without trace.

Such materials produce a strong false-bonding, in which there is an impression that “Ireland sank”. Although the reader will know that this was not the intended anaphoric relation, and that it is effectively ruled out as a final interpretation by the condition sank without trace, there is still a strong impression of false bonding. The effect is also reflected in reading times for falsely bonding target sentences: Times are much longer than for controls in which there is no suitable false antecedent, as in (11):

11. Harry was sailing the seas. It sank without trace.

The phenomenon is not restricted to examples where the intended referent is merely implied, as the following indicates:

12. If the books are too difficult, don’t get your knicker’s in a twist. Leave them in the library and go for a walk.

These examples can be interpreted in the following way (Sanford et al., 1984): When a pronoun is encountered, it immediately triggers a process which is effectively seeking a match in terms of number and gender, where the major candidate is that which is in focus. Although other processes may be recruited to solve the resolution problem, the matching process will
predominate. Indeed, it could be argued that the phenomena are strong
evidence for an immediate resolution process which becomes the subject of
reassignment when more evidence appears—a kind of garden-pathing.

Further work casts severe doubt on this account. Sanford (1985a,b)
showed that if a sentence initial pronoun turns out to be non-coreferential,
as in (13), then there is no trace of the sounds-like effect associated with
false-bonding:

13. Harry sailed to Ireland. It_a was a beautiful day.

There is no trace of a subjective problem, and no trace of a reading time
problem either. It might be argued that this case is different from the
earlier ones because the pronoun is not referential. But if on the original
argument, bonding began at point a, then why did it not begin at point a
with the present example? The processor would have no way of knowing
whether (10) or (13) was the material at hand. An account which preserves
the undeniable existence of false bonding, and yet allows the lack of an
effect in examples like (13), might be based on a two-part resolution
theory. On encountering a pronoun, a match is sought between its princi-
ple characteristics (number, gender) and possible antecedents, with the
most likely candidate match being determined by foregrounding and focus.
If a match is found, then a site has been discovered for the development of
a semantic relationship (like anaphora). However, in the present cases, the
relationship is not instantiated until evidence coming in later demands it.
Therefore, in the usual case, later evidence will suggest a referential
interpretation, and if this is tested at the site (established link), then all will
fit together. In the case of the false bonding examples, instantiation of the
required referential relationship will result (ultimately) in the discovery
that the site is not the right one, hence the disturbing effect. Finally, in
the non-referential cases, a referential relation will never be tested, and
therefore there will never be a false bonding effect.

Although this argument is speculative, the evidence does seem to
support the early initiation of a matching process, distinct from a process of
reference resolution (such a process might be being detected by some of
the priming task results). Because the task is indirect, there is no real way
of knowing that the matching process was initiated as soon as the pronoun
was encountered, even though it is only the information accessible from
the pronoun which is involved. An alternative might be to suppose that the
pattern match is just a dominant process (encapsulated) that happens after
some (unspecified) delay following encountering the pronoun, and imper-
vious to evidence running against an alternative assignment. While it may
indeed be a dominant process (the impression of false bonding does not go
away in the face of new evidence), it would be extraordinary if its onset
were purposely deferred until after the arrival of information which the
process was going to ignore! In summary, there is indirect evidence for immediate initiation of a process linking pronouns with potential antecedents, but not necessarily leading to an instantiated semantic relationship.

There is also a little evidence suggesting bonding effects with nounphrases as well as with pronouns. Sanford (1988; in prep.) discusses cases in which there is a weak parallel to false pronoun bonding:

14. The car came tearing around the bend. It almost hit a car.

In a series of studies on the acceptability of materials, (14) obtained low ratings. The reasons given were that the second occurrence of car leaves the impression that it is not clearly enough signalled as different from the first car (see Garrod & Sanford, 1977, for reading time data showing that the two nounphrases are being compared). Despite the fact that the pronoun is in the sentence-initial position and the action rules out coreference of the object, some automatic process seems to bring the two together. Of course, such a process is far from nonsensical. It has to take place to recognise the following close relative as an instance of identity of sense rather than identity of reference:

15. The car came tearing around the bend. It almost hit another car.

This case demonstrates how some sort of sensible relation can hold between the two instances of car. The underlying mechanism which spuriously links the instances in (14), and sensibly links them in (15), may depend upon a simple pattern match, simpler even than that which we speculate underlies the pronoun bonding effect. But what kind of object is the link? Unlike the pronoun example, in the absence of a coreferential environment there is some impression of referential confusion. This suggests that, whereas in the case of pronouns the bond formed is relatively unspecified, with nounphrases the link is restricted to a class of relations including identity of sense and identity of reference (but with which undecided). Unless the cues strongly support one or the other, the utterance will be unsatisfactory.

**DISCUSSION**

The evidence from the priming and spelling error detection tasks in reading suggests that with full nounphrases, there is an early or immediate initiation of reference resolution processes. With the former, the strongest support must come from the presence of priming of action terms from the same proposition as the antecedent before anything after the anaphor is presented. With the second task, errors are detected on verbs immediately following anaphoric nounphrases, and therefore information regarding the role being played by the character denoted by the anaphor must have been
immediately available. Tyler and Marslen-Wilson’s (1982) evidence from speech is in line with this, but it may include a contribution from the verb.

Pronouns present a more complex picture. There is good evidence from a number of sources for the immediate instigation of some processes which might be considered components of reference resolution. One complication is that top-down influences strongly affect the pattern of processing. There is consistent evidence that with character-based narratives, the resting bias is towards main rather than secondary characters. Therefore, the use of a proper name rather than a role description seems to facilitate pronominal (but not repeat-name) anaphora. Clause-by-clause reading times showed a strong bias towards agents (Hudson et al., 1986). But perhaps the most compelling illustration of the influence of main characters comes from the spelling error study by Garrod and Sanford (1983). This provides fairly direct evidence for immediate resolution, but only providing the pronoun refers to the main character—otherwise, resolution seems to be delayed. Our interpretation of this is that pronouns, when encountered, trigger an immediate mapping on to the main character, and if subsequent data rules this out, then a bottom-up assignment is made. Subsequent data may be gender information from the pronoun, and pragmatic information from the verb.

The immediacy question is further complicated for pronouns by evidence that although processes supporting resolution may be initiated on encountering a pronoun, full resolution may depend upon later evidence. Indeed, there is some indication that even when unambiguous resolution is possible, later evidence may be taken into account in making a final assignment. Regrettably, this evidence comes from overt assignment tasks, which are arguably very artificial. However, studies of speech by Marslen-Wilson and his colleagues show in a very detailed way how successive cues alter the apparent commitment of the system to particular biases in interpretation. A third strand of evidence, perhaps a little more indirect, comes from the studies of the bonding effect summarised in Sanford (1985b). Although there appears to be an immediate (pronoun-initiated) bonding effect, perhaps along the lines needed to explain the thematic subjecthood effect in the spelling error task, this does not appear to amount to the establishment of a full-blown identity of reference relationship.

The evidence thus supports a version of the immediacy hypothesis: Some processes, apparently relevant to reference resolution, are initiated by the appearance of a definite expression (pronoun or nounphrase). In the case of nounphrases or proper names, a process equivalent to resolution appears to be detectable, in that the process produces a pipeline through to information about the actions and the state of the character denoted by the referent. In the case of pronouns, the early process seems more akin to
specifying a locus which is interpretable semantically either on the basis of
default system-states (top-down influences), or in terms of later input.
There is no evidence against this weak version of immediacy, and such
evidence would require the demonstration of deferral of any relevant
processing until some critical point (such as a clause boundary or a
sentence boundary). To go further in our analysis of immediacy, we need
to consider the more general implications of these findings for anaphor
resolution in a broader context.

The structural analysis of discourse has identified a number of devices
which appear to be necessary for producing a coherent representation of
that discourse. One of these is anaphora: Correctly identifying the rela-
tions among sets and individuals seems to be vital for both internal
coherence and external correspondence. Correct identification is a major
component of understanding. This has naturally led to the idea of anaphor
resolution as a separately identifiable process in its own right.

It is this assumption which really motivates the functional argument for
immediacy in relation to anaphora. Clearly, if anaphor resolution is seen as
a major goal, a process in its own right, then it makes sense to suppose that
in so far as it is possible, resolution will go on to completion as soon as the
appropriate trigger conditions are met. If the resolution turns out to be
wrong, then reassignment will have to take place. But such a theory
depends upon anaphor resolution being the key to other aspects of
interpretation, rather than other processes being the key to anaphor
resolution. However, it can be readily argued that there are other candi-
dates for key processes, such as the establishment of causal and temporal
links, and the assignment of entities to case- or theta-roles, so the very
serious question arises as to which key process takes precedence over any
other. This, of course, is the multiple constraint satisfaction problem
currently enjoying exploration in connectionism.

The problem can be sensibly approached by looking at immediacy in
terms of its functional significance at the message level. That is, the
processor should try to establish significance at the message level as early
as possible, regardless of how this is achieved. Precisely what this means is
an interesting question in its own right. But for present purposes, it means
that we should be careful about the assumption that early reference
resolution is a major goal (let alone the major goal). None of this means
that resolution processes should be deferred, and it certainly does not
mean that processes supporting resolution should not be initiated
immediately. Indeed, the processing load arguments for immediacy hold at
all levels of processing. One would expect each bit of the input to have an
immediate impact, depending upon the current state of the system (e.g.
focus and main characterhood in the present context).

These arguments about functionality are important for the immediacy
question, because they suggest an account where immediacy of initiation is going to be the rule for all meaningful input triggers, but where what happens next will vary a great deal, depending upon the current system-state, and the impact of any new input. This fits very nicely with the nounphrase/pronoun differences unearthed throughout this paper, and also reflects some existing proposals from Marslen-Wilson et al. (1982) about pronoun resolution. They argue that in a

distributed processing framework, the lexical information carried by pronouns no longer functions in an all-or-none fashion to preselect candidate antecedents. Rather, the pronoun contributes just one of several inputs to a distributed utterance resolution procedure, whose outcome depends on decision criteria that cannot be satisfied just by information carried by the pronoun alone.

There is an additional problem for the view that reference resolution can be treated as an isolated process, because its outcome may be very different under different circumstances. What precisely is the relation calculated for the following pair, for example?:

John bought the new Hoover vacuum cleaner.
He saw it in the electrical store window.

Was the one which John bought in the window? Who knows. Although we might argue for a default (and argue about a default), we could accept a number of possible relations between or among the relata. This is a problem for a theory holding that some processor has a specific goal to resolve references by specifying a semantic relationship between anaphor and antecedent. Such a theory is tantamount to the claim that there is an evidence-accumulating machine (a “specialist”) aimed at evaluating the fit of possible relationships over possible antecedent–anaphor pairs, and this requires the specification of the relationship. Rather than postulate a specialist which has to produce a categorical outcome, we might argue for a restriction on possibilities; the linguistic evidence rules out possible relationships, rather than specifying one in particular.

It is possible to describe the various types of anaphoric expressions within this framework. For zero anaphors, the constraints forcing the post-gap material on to the surface subject eliminate the need for any explicit signal. The locus is fixed, and the relation, by default, is restricted to identity of reference. With personal pronouns (at least in sentence initial position), the default locus for testing relations is the thematic subject, but the presence of a pronoun allows a switch to be tested for. The range of possible relations is large, but in most instances amounts to identity of reference, simply because of the kind of potential computable relations
that normally hold between antecedent states and what is being added (for some exceptions, note the bonding discussion above). Full nounphrases restrict relations even further, effectively to identity of sense or reference.

Much of this could be accomplished by a pattern-matching mechanism forging initial conceptual links between anaphoric expressions and potential antecedents, serving as loci around which more specific semantic analysis might take place. The attraction of this alternative is that it dispenses with the need for an anaphor-resolving specialist, which itself would require an arbitrary and complex relationship-tester as a component. The pattern-matcher itself could be regarded as real-time, hence "immediate", and could be realised within a connectionist framework. The significance of this formulation is that anaphor resolution becomes just a way of describing part of a more general process of sentence resolution (Marslen-Wilson et al., 1982) which relies upon constraints in the world and in the utterances of the producer to solve the problem of reference to the required degree of accuracy. Oakhill, Garnham, and Vonk (this volume) present arguments which further illustrate the constraint approach, albeit from a different perspective, and Sanford (in press) discusses a similar approach to inference in general.

REFERENCES


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