Focus and Coherence in Discourse Processing

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Offprint

Walter de Gruyter · Berlin · New York
1995

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Focussing and the Process of Pronominal Resolution

1. Introduction

Discourse comprehension implies encoding the surface structure of the text and constructing a mental discourse model which is a conceptual surrogate of the world portrayed in the text (e.g. Garrod & Sanford, 1988a). Once a mental model (Johnson-Laird, 1983, 1989) has been developed during reading or listening, it is important to integrate the concepts and sentences encoded subsequently. On the text surface particular expressions serve to relate different parts of the text. Examples of such expressions are noun anaphors or referential pronouns (e.g. Müsseler & Rickheit, 1990a, b). There is some evidence that noun anaphors activate a lexical level of representation first, while *pronouns* are more directly linked to the conceptual representation of the antecedent (Cloitre & Bever, 1988). In this sense pronouns serve to facilitate discourse comprehension in a more direct manner than do noun anaphors.

Although pronouns certainly facilitate discourse comprehension on the whole, they nevertheless confront the cognitive system with the problem of identifying the concepts they refer to. The relation between the pronoun and the discourse passage has to be examined in order to isolate the reference concept and to construct a coherent representation. In both written and spoken language, pronouns are mostly used anaphorically, i.e., they refer to concepts that were mentioned earlier in the sentence or in one of the preceding sentences. In the present contribution this anaphorical *process* of pronominal resolution is conceptualized on the basis of current psycholinguistic theories, whose cardinal assumptions will be summarized in five theses. In principle, these theses are part of most approaches, be it explicitly or implicitly. In contrast to these theses a sixth thesis will be added which claims that pronominal resolution results directly from the language comprehension process and does not require any specialized mechanisms.

2. Five process theses of pronominal resolution

Due to the sequential nature of the text input during reading or listening, it is not before reaching the anaphor that the cognitive system is confronted with the problem of resolving the pronoun. Most of the theories conclude that anaphoric resolution is initiated just then. Therefore, Just and Carpenter (1980, 1987, cf.

also Carpenter & Just, 1977) interpret their results gained from eye movement experiments in relation to a multiple-processing-levels model. The information is encoded, related to semantic contents, and stored in memory. The authors postulate that the processing of a word starts on all levels *immediately* after reception ('immediacy assumption') and that the processing time of a word is reflected in its fixation time ('eye-mind assumption'). Following the immediacy and the eye-mind assumption, pronoun resolution is not only initiated by the encoding of the pronoun but is also largely terminated by reading it.

These postulations have been challenged empirically as well as theoretically: Ehrlich and Rayner (1983) assume that eye movements serve to supply information to a storage which can then be referred to in the course of complex text processing. In this way semantic processing and the resolution of reference can lag behind the encoding of the anaphor (Rayner, 1978; Stevenson & Vitkovitch, 1986; Carroll & Slowiaczek, 1987; Duffy & Rayner, 1990). Recently, the idea of a related 'cognitive lag' has been advanced by Sanford and Garrod (1989, see below).

While some investigations provided evidence in favour of the immediacy assumption (Carpenter & Just, 1977; Kerr & Underwood, 1984), others did not (Stevenson & Vitkovitch, 1986; Carroll & Slowiaczek, 1987). However, this aspect shall not be discussed in detail at this point. Instead, we will now sum up a first thesis which is based on the conservative assumption that the resolution process is not triggered until the anaphor is reached.

(1) The initiation:
Pronominal resolution starts with the encoding of the anaphor

Due to the contradictory empirical results, the exact time of anaphor resolution will have to be left open in this first thesis (see Sanford & Garrod, 1989; Sichelschmidt & Günther, 1990). All this thesis postulates is that the encoding of the pronoun initiates the resolution and that beginning at that point in time the referential access is improved by enhancement of the antecedent activation and suppression of the non-antecedents (Gernsbacher, 1989), no matter where or when it is completed. On the other hand, this makes the thesis sound somewhat trivial – we decided to stress this point, however, with a view to an alternative thesis that will be dealt with later in the text.

The first thesis confronts us with yet another problem, namely what information is considered during processing. Several authors agree that resolution implies some sort of recourse, i.e., the resolution mechanism is directed *backwards* to concepts that exist in the previous surface representation or discourse model. They assume that in the first stages of processing the appropriate referent is provisionally identified (Ehrlich, 1980; Sanford, 1985; Just & Carpenter, 1987; Sanford & Garrod, 1989). Gender and number are 'primitive characteristics' (Sanford & Garrod, 1989, p.255) the resolution process is orientated at first. In the simplest case, the resolution can indeed be based only on these syntactic features. At this stage of processing, however, the appropriate referent is seen only as a provisional

substitute for the anaphor. Sanford (1985; Sanford, Garrod, Lucas, & Henderson, 1983) refers to this process as 'bonding'; it takes place without recourse to semantic information. One characteristic of 'bonding' – and maybe the essential result of this subprocess – is that it reduces the set of potential referents. This implies another aspect which seems to play an important part during pronominal resolution: Identifying the appropriate referent can be regarded as some sort of *search procedure*, i.e., some concepts are taken into consideration as potential referents, others are ruled out. This leads to the second thesis:

(2) In backward search of 'primitives':
A preliminary assignment results from the surface representation

There are several authors who explicitly refer to antecedent resolution as a 'search process'(e.g. Clark & Sengul, 1979; Frederiksen, 1981; Hirst & Brill, 1980; Garrod & Sanford, 1982; Corbett & Chang, 1983; Sanford, 1985; O'Brien, 1987; Matthews & Chodorow, 1988; O'Brien, Plewes, & Albrecht, 1990); implicitly, the notion of search process is part of almost all approaches. The reference concept can be identified by an *'exhaustive'* mechanism, comparing it with all concepts of the current text representation, or it can be *'terminable':* As soon as it has been identified, the mechanism is stopped; this means that not all possible concepts have to be included in the comparison. 'Exhaustive' vs. 'terminable' procedures have already been discussed in other fields of psychology (cf. e.g. Sternberg's memory scanning paradigm, Sternberg, 1967, 1975). They are also being considered with respect to pronominal resolution processes (Matthews & Chodorow, 1988).

The second thesis basically proceeds from the assumption that in pronominal resolution primitive text characteristics are involved. Ambiguities prove, however, that such a simple resolution mechanism is insufficient.

(a) Susan was lying under the oak and thought of her sister.
She *was almost hit by a branch that dropped.*

If one checks the example text concepts with regard to their correspondence in pronominal number and gender, one finds 'Susan' and her 'sister' as the two potential reference concepts. In other languages, e.g. in German – even the 'oak' could, in principle, be regarded as a potential reference concept, its gender being feminine. Thus, the German pronoun 'sie' would have no less than three potential referents in the preceding sentence. In longer texts the number of possible antecedents can become immense. For the processing system it is therefore necessary to further reduce the number of possible referents by 'elaborative' mechanisms. On the other hand, in some cases an extension of the referential range may be required. In the example

(b) Susan went to the consulting hour.
He *gave her tablets for her headache.*

there is no referent for the pronoun 'he' on the text surface. In this case, pronominal interpretation requires *inference* based on world knowledge (e.g. Hirst & Brill, 1980; Sanford, 1985), by which 'he' can be identified as a male member of the doctor's practice, probably the doctor himself. In this case text, comprehension depends on an extension of the current representation, taking into account more than just textual information. These *elaborative restrictions* or, as the case may be, *extensions* ('elaboratives', cf. Sichelschmidt & Günther, 1990) of the reference domain lead to the next thesis:

(3) Backward search with 'elaboratives':
Resolution considering the discourse model and inferences

The elaborative extensions and restrictions of the number of possible referents has been conceptualized differently in discourse processing theories: van Dijk and Kintsch (1983, cf. also Kintsch, 1988) claim that pronominal resolution is a search procedure that has recourse to several different memory areas. Firstly, the referent can – usually – be identified by scanning and comparing relevant information in the working memory. Secondly, if this procedure is unsuccessful, the system tries to retrieve information from long-term memory of the discourse, or, thirdly, it can draw inferences from world knowledge or the situation model. Thus, at first, the search operation is restricted to the information being focussed on within the working memory (e.g. Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Sanford & Garrod, 1981; Glanzer, Dorfman, & Kaplan, 1981; Monsell, 1984). Its limited capacity is in correspondence with the working memory's functional relevance as the primary reference domain (cf. also Glanzer, Fischer, & Dorfman, 1984). When being focussed on, pronouns are used in the activated context of the preceding sentence. When this is not the case, nouns or complete nominal phrases are normally preferred (cf. also Marslen-Wilson & Tyler, 1980a, Marslen-Wilson, Levy, & Tyler, 1982).

The idea of restricting the potential referents of a pronoun to a limited focus[1] has also been advanced by Sanford and Garrod (1981; Garrod & Sanford, 1982, 1985; Sanford et al., 1983). For determining a referent, different sources of information can be consulted at different stages. The first area is called 'explicit focus' containing representations of entities and events that were mentioned in the directly preceding passage. The explicit focus has a limited processing capacity – a feature it shares with the similarly restricted working memory (see above). If a referent can be identified, Sanford and Garrod (1981) would attribute the pronominal resolution to the primary processes. In other cases, however, pronouns refer to information beyond the 'explicit focus' as Sanford and Garrod (1981) see

[1] The term 'focus' as used in this article is to be interpreted psychologically. This interpretation differs from the linguistic one, especially that of the Prague School (e.g. Hajikova & Sgall, 1984), who try to isolate the focus on the text surface. They understand 'focus' – in contrast to its use above – as new information which explicates the topic, i.e. the subject of a discourse passage.

it – or they refer to what is not contained in the working memory according to van Dijk and Kintsch (1983). In those cases, pronominal resolution can only take place when information inferred from prior knowledge is drawn upon (the 'implicit focus', or rather: the long-term discourse memory and the world knowledge). Here, Sanford and Garrod (1981) speak of secondary processes of pronominal resolution which provide the relevant information by more time-consuming processing mechanisms (cf. also Garnham & Oakhill, 1985, 1988).

Several researchers do not seem to be satisfied with the restrictions and extensions of the reference area mentioned above. As a supplement, they offer particular search rules which are meant to facilitate finding the antecedent.

(4) Directed backward search:
Relating the pronoun to preferred antecedents

The central aspect of this thesis is that there are *preferred* antecedents that are derived from the preceding text and thus include primitives and/or elaboratives. In fact, this fourth thesis combines the second and the third and adds the aspect of *directedness*. This implies that neither structural features of the cognitive system (such as working memory or focus) are stressed nor processes (such as simple assignments on the text surface and inferences), but rather the extensive interrelations between syntactic, semantic, and cognitive aspects during information processing, *even before* the encoding of the pronoun takes place. Van Dijk and Kintsch (1983, p. 171) assume, for example, that particular positions are favoured as reference concepts, like the concept last mentioned or the main proposition, but also the first position, the subject, the agent or the thematic nominal phrase. Similar lists were proposed by Sanford and Garrod (1981, p. 141) or Just and Carpenter (1987, p. 207).

The main question for our purposes is *when* exactly such information becomes evident. According to Sanford and Garrod (1981, pp. 141; see also Caramazza, Grober, Garvey, & Yates, 1977; Garrod & Sanford, 1988b; Crawley & Stevenson, 1990a, b), topicalisation, foregrounding, emphasis, primacy, and recency are factors that become relevant in the working memory even *before* the pronoun is encoded; but only to the effect that they 'guide' the search process. According to Just and Carpenter (1987), so-called 'discourse pointers' take on this function, indicating the focus state of a particular part of a sentence. One element of the referential representation focussed on shortly before has a privileged status in the search for a referent. So here again a marker is placed still within the limits of the focus; a marker by which the effectiveness of the pronominal search process is assumed to be amplified. However, like in the theses discussed so far, it is orientated backwards.

Recent accounts, however, extend the somewhat rigid view of backward search (Bosch, 1988; Oakhill, Garnham, & Vonk, 1989). As has been mentioned above, Sanford and Garrod (1989) postulate some sort of 'cognitive lag' resolution. Their basic idea is that after encoding the pronoun, readers or listeners immediately develop a provisional assignment between the anaphor and one

possible antecedent on a syntactic level. This provisional assignment is accepted as the final pronominal interpretation only if it is confirmed by subsequent discourse information or knowledge-based inferences. In our example (a) 'Susan' cannot definitely be identified as the antecedent before the reader has reached the end of the second sentence. The final resolution is *'postponed'* (Sichelschmidt & Günther, 1990; see also Vonk, 1985). In this sense the immediacy assumption of pronominal resolution is dropped, but it is not simply substituted by a lag thesis. Instead, readers or listeners are in search of further information confirming the provisional assignment.

(5) Forward search:
Gathering further information from the subsequent discourse

It can happen that a provisional assignment turns out to be inappropriate ('false bonding', Sanford, 1985); in those cases a re-interpretation has to be made. In examples like the following (Wilks, 1975), the most economical processing will be to gather further hints until an anaphor resolution can be safely assumed to hold:

(c) Mary left the window and drank the wine on the table.
It *was brown and round.*

To summarize the five theses: After encoding the pronoun, a search is initiated which is directed backwards or forwards to particular concepts within the surface representation and the discourse model. During processing, the reference domain is restricted or extended within the structural components of the cognitive system and by syntactic and semantic properties of the discourse. It can be assumed that in pronominal resolution different types of information are projected on potential antecedents which are provided by the surface or the deep structure of the discourse representation. Relative acceptability of different antecedents is ascertained 'step by step', i.e. serially (Garnham & Oakhill, 1985; O'Brien, Duffy, & Myers, 1986; Sichelschmidt & Günther, 1990) or parallel (Marslen-Wilson & Tyler, 1980a, b; Tyler & Marslen-Wilson, 1982, Marslen-Wilson, Levy, & Tyler, 1982).

The different theses dealt with so far do not necessarily have to exclude one another – in fact, they can perfectly complement one another. In the following, the search mechanism – which represents the underlying presupposition of all five theses – is contrasted to another mechanism.

3. The sixth process thesis: Pronominal resolution results from pronominal occupation

In contrast to the first five theses, the sixth thesis suggests a mechanism of a different kind. It is based on the assumption that a search process does not necessarily have to be involved in the resolution of anaphoric pronouns – that it

is even the exception rather than the rule in normal discourse processing. In some cases, a restriction of the reference domain can cause a qualitative change in the pronominal resolution process, especially when the reference area has been restricted to only one concept *in advance.* In those cases, a search procedure will no longer be necessary, as 'search' always implies considering several alternatives and selecting one of them.

The relevance of the extra search component is nullified when the connection between the reference concept and the pronoun already holds. Before the pronoun is encoded, potential antecedents may be definitely specified and thus be determined with regard to the succeeding discourse. This corresponds to the idea of the so-called 'pronominal occupation' (Müsseler & Terhorst, 1990; Müsseler & Rickheit, 1990a), according to which the resolution process starts before encoding the pronoun, i.e. the resolution was prepared for – and, strictly speaking, performed – during the preceding comprehension process. The problem should be shifted from 'How is a search process triggered by a pronoun?' to the question 'How is the discourse model constructed to make use of pronouns?'. On the basis of this formulation a related framework has been recently developed by Greene, McKoon, and Ratcliff (1992) and – prior – by several computational linguists (Sidner, 1983a, b; Grosz & Sidner, 1986; Grosz, Joshi, & Weinstein, 1983; cf. also Schnotz, 1986; Gordon, Grosz & Gilliom, 1993; see below).

In a sequence model, the point in time the 'resolution' takes place should no longer be seen as beginning with or after the pronoun – like the assumptions dealt with in the previous section. Instead, it is proposed that resolution starts earlier. A search mechanism is then no longer necessary. From a psycholinguistic point of view, a resolution sequence thus modified may seem somewhat strange. However, seeing it, for example, in relation to a neural network, this approach seems very plausible. When reading the sentences

(d) Susan went to the consulting hour.
She *is suffering from a headache.*

'Susan' is specified as a female singular entity. This also activates the 'she'-knot – which bears exactly these features – before the pronoun actually occurs. So, before its reception, 'she' belongs to the activation concept of 'Susan'. It is also possible that in a semantic network referent and pronoun form a knot in advance. Then also 'Susan' and 'she' are related to each other directly and pre-pronominally – a search for the antecedent is no longer necessary. This exactly is the point which remains unconsidered in the previous theses on pronominal resolution, or rather: which goes beyond them.

To contrast search process and pronominal occupation, imagine a parser simulating word-by-word processing during reading (e.g. Aulich, Drexel, Rickheit, & Strohner, 1988). In reading, the necessity of identifying the corresponding reference concept does not arise before one reaches the pronoun in question – a fact owing to the reception's sequential character. The question then has to be: How could a resolution algorithm find the corresponding reference concept?

Following the five theses above, it will probably first match the anaphor with previously read concepts (listed e.g. in a buffer which corresponds to the working memory or explicit focus). Other information of other sources may be added in a second step. However, in these steps the computational answer is one of a backward search procedure.

Imagine further that according to the fourth thesis a second pre-pronominal algorithm is installed to isolate only a few items for the buffer. In a very elaborated version it sometimes happens that only one item is available. Thus, this item could be a prime candidate for pronominal resolution. Indeed, Sanford and Garrod (1981) try to evaluate their explicit focus with examples where this seems to be the case. But a different resolution algorithm is not assumed as it checks all items in focus against the anaphor, independent of the number.

Not so in pronominal occupation: In this case, pronominal resolution is performed earlier. The main difference is that during pre-pronominal reception the relevant text concept will already be assigned to a local pronoun variable. Thus, contrary to global word concepts, those meanings do not vary with the text context to such an extent, that pronoun interpretation is temporarily pre-determined. As a consequence, for the current word processing there should be no difference between the reception of nouns and pronouns. That is to say, when the pronoun is read a specific resolution algorithm need not be initiated as it is simply unnecessary[2].

Of course the question is, which text concept a pronoun occupies. The answer is as difficult as the installation of the second pre-pronominal algorithm above which is used to simulate the fourth thesis. The problems there are similar to those of the occupation assumption. If there is no ambiguity in the discourse, the situation is quite clear. But, of course, even linguistic ambiguity does not always mean cognitive ambiguity. Clearness is already reflected on the text surface by pre-pronominal signals, i.e. by foregrounding (Sanford & Garrod, 1981; Glenberg, Meyer, & Lindem, 1987), implicit causality (Caramazza et al., 1977; McKoon, Greene & Ratcliff, 1993) or complexity of the antecedent (Garrod & Sanford, 1977; Reilly, 1988). The empirical question is: which information resulted in pronominal occupation? Nevertheless, in contrast to the search algorithm, the occupational realization leads to a completely different architecture of the simulation process. Pronominal occupation is settled along with normal text parsing and is performed incidentally.

The idea of pronominal occupation should be further clarified. At first sight, pronominal occupation appears to activate future text concepts – this, however, does not actually happen: There are no expectations established with a view to pronouns to be received later (cf. the so-called forward or expectation inferences, e.g. Carpenter & Just, 1977; Clark, 1977; Singer, 1980; Singer & Fer-

[2] Indeed, such a parser already exists. It is implemented in a text adventure ('The Pawn', Magnetic Scrolls Ltd., London) and surely has not been developed to simulate human discourse processing. But, in principle, the occupation idea is realized in this game (cf. Müsseler & Terhorst, 1990).

reira, 1983; Rickheit, Schnotz, & Strohner, 1985; van den Broek, 1990). This has nothing to do with pronominal occupation. 'Occupation' rather suggests that a pronoun is sufficiently specified in advance by text information without suggesting that it actually occurs in the text to follow. However, if a pronoun does occur it is clear right away which concept is being referred to, due to the occupation mechanism. After all, the connection had already been made.

So, strictly speaking, the term 'resolution' is inappropriate in this context, as after the encoding of the pronoun no additional selection, search, comparison or assignment mechanisms are required. From a cognitive point of view, this notion is much more attractive than an extra resolution mechanism, as the normal reception cycle is not subject to any further expenditure in the service of anaphoric assignment. 'Resolution' is rather to be regarded as direct and as a part of the normal text comprehension process.

4. Empirical evidence for the search and the occupation assumption

Cognitive evidence for a search or an occupation process has to be derived from on-line data, i.e. from studies investigating eye movement, reading time or reaction time. In the following it will be shown that a search mechanism is a plausible interpretation of the empirical findings, but not a cogent one. In particular, there are no indications at all that a search process has to be inevitably involved in every case of pronominal resolution.

According to Carpenter and Just (1977), reading a pronoun is followed by eye movement regressions in no less than 50% of the cases. Such regressions are obvious indicators for backward references that belong to the *text surface.* However, Ehrlich (1983) as well as Murray and Kennedy (1988) found a ratio of pronominal regressions that lies far below that value (approx. 10% and approx. 30% respectively). Apart from that, it has been shown that also in experimental reading conditions that exclude eye regressions, text comprehension and establishing referential relations within a text are possible (e.g. by using the 'moving-window' technique, cf. Just, Carpenter, & Woolley, 1982; Ward & Juola, 1982; Müsseler & Nattkemper, 1986; Ferreira & Henderson, 1990).

The occurrence of eye regressions can, in any case, be considered no more than an indication that mechanisms directed backwards contribute to pronominal resolution *from time to time.* It does not necessarily mean that this process always has to be a search process. Moreover, it does not strongly indicate a search process: A search process on the eye level is not characterized by regression to the one antecedent (which at that moment is already identified as such!), but should involve other regressions to other potential reference concepts, too. However, there is not much evidence for this as yet.

In any case, a search process does not necessarily reveal itself in eye movements. Instead of scanning the text surface with the eyes, the text representation can of course be matched. In these cases, a more extensive scanning procedure

should be accompanied by increased fixation and reading times of the pronoun. Indeed, a bigger spatial distance between the pronoun and the referential concept leads to an increase in processing times (e.g. by inserting additional sentences or parts of sentences; cf. Clark & Sengul, 1979; Daneman & Carpenter, 1980; Ehrlich, 1980; Ehrlich & Rayner, 1983; Glenberg et al., 1987; O'Brien, 1987; Yuill & Oakhill, 1988; O'Brien et al., 1990). This is an indicator for pronominally initiated search processes. But, for this interpretation it is also assumed that the pronominal assignment is performed on a mental text representation analogous to the text surface. Otherwise, an increased search process could not be conclusively postulated here.

An increase in fixation and reading time of the pronoun as a consequence of reference ambiguities has also been regarded as evidence in favour of pronominal search processes (e.g. Caramazza et al., 1977; Ehrlich, 1980; Corbett & Chang, 1983; Matthews & Chodorow, 1988; Crawley & Stevenson, 1990b). In this case, congruence of mental representation and text surface can no longer be claimed. Here, one first of all has to make sure that a referential resolution takes place at all. Moreover, the increases in processing time may not just be the result of a more elaborate comparison process, but may, to a large extent, be caused by the readers' irritation due to the violation of general linguistic conventions.

In spite of this vagueness, the existence of a search process in pronominal resolution shall not generally be questioned here, either. Especially when it comes to extending or restricting the reference domain, a comparison with the concepts of the current text representation seems to be indispensable. Whenever there are several potential reference concepts – or none at all –, another resolution can hardly be imagined. To produce significant processing differences, most empirical investigations in this field used texts where the referential definiteness was restricted or even replaced by ambiguity. Texts of this kind offer the reader several alternatives (or even unusual concepts) for reference resolution. The fact that with an increasing number of these alternatives the processing (or search) time increases as well, can be regarded as a result of the extension and restriction processes. This, of course, is not denied here.

On the other hand – is there any empirical evidence for pronominal occupation? If the assignment has already been established, no processing difficulties should be observable at the pronoun. On the contrary – any kind of search process should produce an increase in processing at that point. Indeed, in a number of studies no processing difficulties at the pronoun are detectable (Glenberg et al., 1987, Exp. 3 with no filler sentences; Sichelschmidt & Günther, 1990, Exp. 2; Müsseler, Hielscher, & Rickheit, 1995). However, such results are necessary but not sufficient for the occupation idea; they depend on the operationalization of 'processing difficulties' and, of course, for statistical reasons it is problematic to test equalities between means. Fortunately, the occupation idea has another implication: It postulates that a (potential) antecedent is processed and marked pre-pronominally. Thus, Shillcock (1982) found in a lexical decision task that a selective semantic activation of the antecedent already exists before

the pronoun is read. In addition, Sichelschmidt and Günther (1990) show pre-pronominal processing differences but not pronominal difficulties (see below). These results are first indications for the occupation idea.

The finding that sometimes readers tend to skip pronouns during normal reading (Vonk, 1984, 1985) could be interpreted as another indication in favour of the occupation. Neglecting other possible interpretations, this finding reflects from an occupation view that the discourse context specifies the referential relation so clearly that any kind of additional assignment is superfluous. In line with this finding, there sometimes seems to be no definite identification of the antecedent, e.g. of the proper name. Only if the subjects' task was to name the antecedent, did referential effects appear (Müsseler 1995).

Some results from our recent experiments on plural reference corroborate the occupation approach, too (Hielscher & Müsseler, 1990; Müsseler & Rickheit, 1990a, c; Müsseler et al., 1995). First of all, there is no reason to assume qualitatively different mechanisms with regard to the resolution processes for singular and plural pronouns. In view of the search mechanism, however, the resolution of singular pronouns should be easier than the resolution of plural pronouns: Successful search for a singular referent involves a concept which always corresponds to number and gender of the pronoun. As opposed to singular pronouns, there need not be a correspondence in gender and number between plural pronouns and their referential concept, e.g. if two singular concepts are introduced with a preposition.

(e) *John wanted to have a picnic with Mary.*
They *had*...

Obviously, in order to comprehend example (e) the reader has to conceptually unite the singular persons in a way that one can refer to them with a plural pronoun as if it were a plural entity. The process which yields such a plural entity ('installing a complex', see also Kaup, 1994; for a more formal description see Eschenbach, Habel, Herweg, & Rehkämper, 1989, 1990; Schopp, 1995) is an additional component in the text comprehension process which should render the resolution longer than that of a mere singular concept, i.e. referring to Mary alone.

In several experiments (Hielscher & Müsseler, 1990; Müsseler & Rickheit, 1990a, c; Müsseler et al., 1995) we made use of the ambiguity of the German pronoun 'sie', which can refer to 'Mary' alone or to the two individuals in (e) together ('Mary and John'). Only the verb inflexion (in German 'Sie hat...' vs. 'Sie haben...') determines the reference to the singular or the plural concept. If the reaction times for the plural pronoun (or the verb inflexion, respectively) had increased, thus indicating that the installation of the complex was initiated after reading the anaphor, the search resolution would have then been the most likely process. However, the results were the opposite, i.e., there was an advantage for the plural reference. This strongly suggests that the plural complex is installed before the pronoun is read and that the cognitive system is better prepared to process further referential relations. In a more direct manner,

Sichelschmidt and Günther (1990) demonstrate that processing a conceptual compound like

(f) *So Carl took* a lightweight and a waterproof jacket *and put* them *into his suitcase.*

is more time-consuming than processing the comparable singular version:

(g) *So Carl took* a lightweight and waterproof jacket *and put* it *into his suitcase.*

While pronoun processing – here measured in reading time – was not sensitive to variation of the number of implied concepts, antecedent processing was. The noun 'jacket' in example (f) took longer than the one in example (g). Sichelschmidt and Günther (1990) favoured the occupation idea for interpreting pronoun processing. And indeed, a simple backward search assumption cannot explain the results, because two antecedents instead of one have to be picked up and be combined in the examples (e) and (f). If plural occupation is assumed – contrary to a search mechanism – the results are rather simple to interpret.

On the other hand, if we relate the results to the fourth thesis (see above), occupation seems to be no more than one special case: The results only indicate that the cognitive system works more efficiently while processing further referential relations. As far as pronominal resolution is concerned, this preparation could have the effect that the possible plural referent is focussed on or marked in focus by the processing system, which leads to a simple identification of the antecedent as it matches only one alternative. Nevertheless, the assignment is not initiated before the pronoun is encoded – it is restricted, however, to the focussed antecedents. In this way, the assignment process will be no more than facilitated.

This explanation cannot be put aside completely, but it does not seem very convincing. First of all, it is not justified to speak of a backward search process because search implies more than one alternative. Indeed the fourth and fifth theses already begin to soften the rigid search formulation. Moreover, the processing system tends to focus on not only one of the previously mentioned concepts – that would not be astonishing – but rather it compounds two concepts pre-pronominally and makes a preference. One functional reason to install a plural compound is that it could be useful for processing later referential relations. From here it is only a little step further to assume an occupation mechanism.

To summarize, there is only indirect evidence for both, the search and the occupation view. While the search mechanism is well established, e.g. in ambiguous texts and while it cannot be completely ruled out in other, more definite texts, no result forces us to refuse the occupation idea. But as search procedure and pronominal occupation are regarded as incompatible and mutually exclusive resolution mechanisms, a rest of empirical ambiguity is probably inevitable. Nevertheless, further studies will have to clarify the possible relations between search and occupation mechanism.

5. *The function of search process and pronominal occupation*

As should have become clear by now, search procedure and pronominal occupation should not be regarded as incompatible and mutually exclusive resolution mechanisms. Depending on the discourse context and on whether or not a restriction or extension of the reference domain is necessary, the resolution of the pronoun involves either the search or the occupation process. But why – one might ask – should the processing system use two qualitatively different resolution mechanisms? The above explanations have provided a first answer: Since in the case of pronominal occupation no additional processing activities are required, the processing system has at best to find out whether a search process will be necessary or not. Important questions, however, are still left unanswered: What exactly constitutes pronominal occupation? What happens when there are conflicting occupations, as is the case with ambiguity? Can an occupation be withdrawn and under which circumstances would this happen? Which criteria is the search or selection process subject to? These and related questions cannot be answered independently of one another – the key to them lies in the general comprehension process. As will be shown, the questions are not that new either: They are only formulated from another perspective and reflect as yet unsolved problems in a more functional manner.

Important for a resolution via pronominal occupation is a dynamic, pre-pronominal adjustment of the text information just received to the current representation. Here, the processing system is confronted with a constant updating problem which has to be overcome. This problem is similar to the one in previous accounts, where the question is: Which information is transferred to the working memory (van Dijk & Kintsch, 1983; Rickheit, Sichelschmidt, & Strohner, 1995) or the explicit focus (Sanford & Garrod, 1981; Garrod & Sanford, 1982, 1985)? Or, according to the fourth thesis: Which information is the prime candidate for the search process (van Dijk & Kintsch, 1983; Sanford & Garrod 1981; Just & Carpenter, 1987)? There, a potential answer is that factors like topicalization, foregrounding or subject position determine the search. This holds true in the occupation idea with the essential difference that the prime candidate brings about the pronominal occupation. As mentioned, this change lead to a completely different architecture of the resolution process. Whatever the rules for isolating the prime candidate look like, they will have to be put forward and verified by empirical data.

Important for the resolution is the *selection problem* during pre-pronominal comprehension: In order to establish an appropriate representation of the text, the processing system has to constantly check the information just received as to whether it could be integrated into the current text representation or not. A pronoun has a signalling function for the language processing system – however, it does not mainly signal that a search process for the antecedent has to be initiated, but – as a rule – it primarily signals that the *momentary focus can be maintained* (Sidner, 1983a; Schnotz, 1986). The pronoun served as a cue to the

most likely entity in the discourse representation. Greene et al. (1992) relate this mechanism to the *automatic processes*. Thus, a referential search procedure could be rather the exception than the rule in normal text comprehension.

The problem of selection has already been pointed out by Sidner (1983a, b; cf. also Grosz & Sidner, 1986; Schnotz, 1986). Her basic assumption is that each text segment received is checked as to whether or not it agrees with the present focus content. If it does, it is simply assigned to the already existing focus. Only if it is incompatible with the focus, is a process initiated which finishes with establishing a new focus. Following this line, Schnotz (1986) speaks of a *'topic shift'* which results from *'focus tracking'* (cf. Sidner, 1983a, b), from *'focus shifts'* (cf. Anderson, Garrod, & Sanford, 1983) or from *'strategic processes'* (Greene et al., 1992).

Of course, the notion of focus is only a heuristic one. Here, it denotes the current text representation which is limited in size and is accessible for referential consultation. It results from the text comprehension process and is subject to continual adjustment on the part of the receiver (Sidner, 1983a, b). On both the text surface and the level of the semantic representation there are a number of signals that induce either a shift or a maintenance of the focus. The search process aimed at a reference object can be regarded as an *indication of focus tracking* (expressing the selection process for the focus), the pronominal occupation or the resulting 'resolution' can be considered an *expression of focus (or topic) maintenance.*

The most obvious reason why the focus content has to be continuously related and adjusted to the text content is the fact that it can be regarded as a part of the working memory, which implies that it is subject to a capacity limitation (see above). However, the relation between capacity limitation and selection has to be considered from a functional point of view: In order to serve the comprehension process, selection mechanisms produce capacity limitations[3]. It should be taken as a fact that selection mechanisms are of considerable benefit to any language processing system preventing it from freezing, as it were, in view of the huge number of potential reference and coherence possibilities. One major economical factor in text processing is to actively reduce the capacity of the working memory in such a way that old and new information is accessible for text integration to an equal and adequate degree (Monsell, 1984; Rickheit et al., 1995; Herrmann & Grabowski, 1994, Chap. 7; Glenberg & Kruley, 1992).

The advantages of pronominal occupation (rather: of the 'resolution' it initiates and, in case of agreement, also performs) are to be found in the ease and effectiveness in which anaphoric relations are preserved in most of the cases. Search processes do not have to be initialized until an incoherence in the actual

[3] This idea is similar to recent considerations made in the field of 'Selective Attention', where at first selection mechanisms were regarded as indispensable as well, since capacity limitations occur in the processing system. Meanwhile this relation has been reversed: Selection mechanisms themselves are regarded to cause capacity limitations (for more detailed arguments cf. Neumann, 1985, 1987a, b, and others). This argument can be applied in the same manner to the focussing of text information, which is of interest here.

text representation is discovered. In this sense, readers are in search of further information confirming the provisional focus (not the provisional pronoun as is postulated in the fifth search thesis, cf. Sanford & Garrod, 1989; Sichelschmidt & Günther, 1990).

6. *Conclusion*

The first five theses show that pronominal resolution can be accomplished by means of a search mechanism. It is questionable, however, whether the search principle should represent the only mechanism. Therefore, the sixth thesis postulates a pro-active process, which accompanies reception of the (potential) antecedent so that the connection between reference concept and pronoun already exists when the pronoun is encoded. Within a network model, the activation of the (potential) antecedent implies the activation of the pronoun.

A distinction of the two processes can be made on a functional basis: Whereas search procedures introduce a focus shift within a discourse and can thus – for instance – be employed for the resolution of referential ambiguity, the 'resolution' of the pronominal occupation type rather signals a focus maintenance. This means that a selection from different reference alternatives becomes superfluous.

The fact that the search process has been judged as the resolution mechanism can be explained with regard to this approach being phenomenon-oriented. After all, for psychologists as well as linguists, the 'phenomenon' basically means the resolution of referential ambiguities. Identifying and isolating the mechanisms that are inevitably involved was considered to be the scientific problem. Certainly the phenomenon-oriented approach can be justified; it should, however, not lead to rash generalizations. Mechanisms the cognitive system uses in those 'phenomenon' cases do not necessarily have to reflect general mechanisms. Recently Greene et al. (1992, pp.280) concluded that so far "...the problem has been to find out how the processing system uses a pronoun to find its referent. Phrasing the question this way puts the burden on processes driven by the pronoun. However, the appropriate question may be to ask not what the pronoun does for the discourse but what the discourse does for the pronoun. When the discourse has only one entity in the focus of attention at the time the pronoun is encountered, then it may be that essentially no processing is required for the pronoun." A clearly related analysis has been formulated by Müsseler and Terhorst (1990, p.47).

The difference between pronominal occupation and search mechanism should by no means be neglected, since both lead to completely different process models. Especially in view of current parser development within Artificial Intelligence, which claims to be of psychological relevance, a decision – and be it only theoretical – is inevitable. We have tried to point out that a pronominal resolution by means of an occupation results from the ordinary discourse comprehension and that it appears to represent a mechanism much simpler than search and comparison processes could ever be. The latter processes, however,

are vital for the resolution of ambiguity and semantic disagreement. Our considerations were not just strictly confined to the problem of reference resolution, we also tried to take into account general mechanisms of the discourse comprehension process. Of course, the occupation idea as such does not eliminate all questions, but at least it shows pronominal resolution in another light. To which extent it will stand up to empirical examination remains to be seen.

Acknowledgement

I would like to thank Eva Terhorst and Hartmut Büscher for their comments on an earlier draft of this paper. Requests for reprints should be sent to Jochen Müsseler, Max-Planck-Institut für psychologische Forschung, Leopoldstraße 24, D-80802 München, Federal Republic of Germany.

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