Noun-Phrase Anaphora and Focus: The Informational Load Hypothesis

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The processing of noun-phrase (NP) anaphors in discourse is argued to reflect constraints on the activation and processing of semantic information in working memory. The proposed theory views NP anaphor processing as an optimization process that is based on the principle that processing cost, defined in terms of activating semantic information, should serve some discourse function—identifying the antecedent, adding new information, or both. In a series of 5 self-paced reading experiments, anaphors’ functionality was manipulated by changing the discourse focus, and their cost was manipulated by changing the semantic relation between the anaphors and their antecedents. The results show that reading times of NP anaphors reflect their functional justification: Anaphors were read faster when their cost had a better functional justification. These results are incompatible with any theory that treats NP anaphors as one homogeneous class regardless of discourse function and processing cost.

The incremental nature of normal discourse requires repeated reference to the same discourse entities in consecutive utterances. Such repeated reference is established through the use of anaphoric expressions, that is, expressions that do not describe mental representations of real-world referents directly but only through coreference with antecedents that have been previously introduced into the discourse. Nominal anaphors can take one of several forms—definite descriptions such as the dog (henceforth, noun-phrase [NP] anaphors), proper names such as Fido, demonstratives such as that dog, pronominal anaphors such as he and it (henceforth, pronouns), or null anaphors. Much effort has been devoted to characterizing the circumstances in which one form of referring expression is used instead of another. The most general finding is that the form of linguistic expression best suited for referring depends primarily on the current discourse focus (Ariel, 1990; Garrod & Sanford, 1984; Gernsbacher, 1989; Gordon, Grosz, & Gilliom, 1993; Grosz, Joshi, & Weinstein, 1983; Gundel, Hedberg, & Zacharski, 1993; van-Dijk & Kintsch, 1983). Because the term focus is often used to describe different concepts in the literature, it is important to note that here the term focus is used to describe the most active and salient entity or entities in the discourse representation, rather than the new information component of a single utterance.

The effect of discourse focus on reference resolution is universally reflected in human languages by the distribution of anaphoric forms according to the salience of their referents (Ariel, 1990; Givon, 1987). On one end of this distribution, unstressed pronouns are almost always used to refer to the most salient discourse entity. On the other end, definite NP anaphors are most frequently used to access nonsalient discourse entities. Indeed, the observation that pronouns are preferable to definite descriptions for referring to the most salient entity in the discourse (i.e., the discourse focus) has been made by numerous researchers (e.g., Gordon & Scearce, 1995; Grosz et al., 1983; van-Dijk & Kintsch, 1983) and is supported by distributional analysis (Ariel, 1990; Grosz, 1981) and experimental evidence (Gordon et al., 1993).

Although much is known about the distributional patterns of anaphoric expressions, the psychological processes that underlie the use of these expressions, and that are therefore responsible for the observed distributional patterns, remain poorly understood. One view (e.g., Gordon et al., 1993; Grosz et al., 1983) is that the relation between the appropriate form of referring expressions and the referent’s salience serves a communicative function—speakers and writers use anaphoric form as a cue to aid listeners and readers in identifying referents. However, although this may explain why speakers make consistent choices of anaphoric form, it does not explain why this consistency follows the principle that the more salient the referent is, the less information is contained in the anaphoric expression. One attempt to explain this inverse relation between anaphor informativeness and referent accessibility is Ariel’s (1990) accessibility theory, which associates different processing costs with different forms of reference; definite NP anaphors are said to have a higher processing cost than pronouns. Estab
lishing reference to a highly accessible entity only requires a low-cost referring expression, whereas establishing reference to an entity that is not highly accessible requires a referring expression with a higher cost. Ariel's accessibility theory is in fact an extension of the more general relevance theory (Sperber & Wilson, 1986, 1995), which claims that most linguistic processing reflects a balance between cognitive function and processing cost such that when speakers perturb this balance, they do it so as to signal some additional information to their addressees. However, neither theory provides an explicit account of the psychological mechanisms that underlie cognitive function or computational cost.

The present study seeks to provide a psychologically motivated and thus empirically testable theory of the mechanisms behind the notions of cost and function in anaphor processing. Like relevance and accessibility theories, the present theory argues that the psychological processes underlying anaphor use reflect the general principle that additional cost must serve some additional discourse function. However, in the present view, this principle is not a maxim that is deliberately followed by discourse participants but rather an outcome of the underlying architecture of the memory system involved in discourse processing. Here, the notion of cost is tied into the processing involved in integrating the semantic representation of the anaphoric expression into the representation of the discourse; cost is associated with the amount of semantic information that is activated by the anaphoric expression and is not arbitrarily associated with different anaphoric forms. The present notion of discourse function is broader than the one suggested by Ariel (1990) in that it is not only identifying the referent but possibly also adding new information. Importantly, the current theory distinguishes not only between anaphors of different kinds (i.e., pronominal vs. nonpronominal anaphors) but also between anaphors of the same kind that differ in their cost or discourse function. For example, the four NP anaphors in Example 1 below differ in their semantic representation (it is more general than bird, which is more general than both robin and wet little bird) and, thus, have different costs. These anaphors also differ in the amount of new information they add (the anaphor the wet little bird clearly adds new information, whereas the anaphors the bird, the robin, and it do not add any information) and, thus, have different discourse function (although note that if the anaphor the bird is used to highlight the general properties of the bird category, it will in fact serve the function of activating new information).

Example 1:

a. A robin ate the fruit. The robin seemed very satisfied.
b. A robin ate the fruit. The wet little bird seemed very satisfied.
c. A robin ate the fruit. The bird seemed very satisfied.
d. A robin ate the fruit. It seemed very satisfied.

Unfortunately, much of what is already known about the processing of NP anaphors in discourse is based on a comparison between pronouns and NP anaphors as a group, a comparison that is based on the assumption that all NP anaphors are processed alike with respect to discourse focus. Indeed, many of the empirical studies of the differential effect of focus on the processing of pronouns and NP anaphors (e.g., Gordon et al., 1993; Gordon & Scearce, 1995) were based on a comparison between pronouns and repetitive anaphors (i.e., anaphors that repeat their antecedent verbatim, as in Example 1a) while overlooking the possibility that nonrepetitive NP anaphors (as in Example 1b and 1c) interact with discourse focus differently than repetitive ones by virtue of serving a different function or having a different processing cost.

The assumption that all NP anaphors are processed alike may be attributed to the common belief that the new information that may be added by nonrepetitive anaphors interferes with processing in some irrelevant way. For example, Cloitre and Bever (1988) studied the difference between pronouns and NP anaphors in the level of the representation they access (deep--conceptual vs. surface--phonological), chose to use repeated noun phrases “in order to evaluate as fairly as possible the potential advantage of a noun-anaphor per se, independent of effects of additional integration activities involving new information about the referent” (Cloitre & Bever, 1988, p. 298). Similarly, in a series of studies done by Gordon and his collaborators (Gordon, 1993; Gordon & Chan, 1995; Gordon et al., 1993; Gordon & Scearce, 1995), pronouns were compared with repetitive proper-name anaphors. The results of these comparisons, however, were used to support and extend the claims of centering theory (Grosz et al., 1983) about differences between pronouns and NP anaphors in general. Whereas the studies described above assumed that repeated NP anaphors could represent the entire class of NP anaphors, other researchers have suggested that repetition may in fact serve a special discourse function—that of reactivating memory representation (e.g., Walker, 1993). Thus, although some previous research treated repeated NPs as the representative case of NP anaphors, other research treated repetition more generally as a unique phenomenon that serves a special function.

The premise of this study is that there is no a priori reason to assume different processing principles for the different kinds of NP anaphors. In particular, I show that there is no reason to assume that the new information that may be added by nonrepetitive anaphors is irrelevant to, and independent of, NP anaphor processing in general. On the contrary, the research reported here shows that new information and discourse focus jointly affect the processing of NP anaphors in a completely predictable way. By this view, the special memory-reactivation function of repeated NP anaphors is not due to a special status of repetition but is rather an outcome of the general processing principles that apply to all anaphors. The proposed theory provides a unified, psychologically, and above all experimentally motivated account of NP anaphor processing that applies to all kinds of NP anaphors.

The Informational Load Hypothesis

The proposed theory, the informational load hypothesis (ILH), claims that the processing of anaphoric expressions reflects a pragmatic principle similar to the Gricean maxim of quantity (Grice, 1975). The maxim of quantity states that speakers should make their contribution as informative as required but not more than required, or in other words that speakers should use the least complex linguistic form that is sufficiently informative for their communicative purpose. Although the ILH does not state that speakers should deliberately follow any conversational principle, it does state that, because of constraints imposed by the underlying architecture of the psychological mechanisms involved in processing anaphoric expressions, anaphor use can be generally described by the maxim of quantity with the following two additions. First,
complexity is expressed by the measure of informational load, a notion that expresses the constraints on the simultaneous storage and processing of information in verbal working memory (Baddeley, 1992; Caplan & Waters, 1999; Just & Carpenter, 1992). Second, the information conveyed by an anaphoric expression consists of information that is required for identifying the antecedent and information that is included as new information about the referent. The pragmatic principle that describes anaphor processing according to the ILH is then: The informational load of an anaphor with respect to a given antecedent should have a functional justification in either aiding the identification of the antecedent, adding new information about it, or both.

This cost and function optimization principle is the outcome of certain underlying psychological processes, most important, processes that use verbal working memory. Indeed, the mechanism of verbal working memory is often claimed to play a role in the processing and distribution of anaphors—many researchers believe that the role of anaphoric expressions, especially pronouns and definite NPs, is to reactivate information that is maintained in working memory and thus establish a coherent link to previous discourse (e.g., Sanford & Garrod, 1981; van-Dijk & Kintsch, 1983). One of the main reasons for this claim is the fact that processing pronominal and definite anaphoric reference becomes harder with increasing distance between the antecedent and the anaphor (Sanford & Garrod, 1981). Such an inverse relation between the amount of intervening linguistic material and the ease of anaphor processing strongly suggests the involvement of working memory because working memory has a limited capacity that is used for both the storage and the processing of information (Baddeley, 1992; Just & Carpenter, 1992). This limited capacity explains why the processing of the intervening linguistic material between the antecedent and the anaphor results in decay of the antecedent representation.

The decay of information in working memory underlies the antecedent-identification aspect of anaphor functionality. Identifying the antecedent is a matter of reactivating the representation of the antecedent in working memory. The weaker the representation of the antecedent is in working memory, the more overlap would be required between the anaphor and the antecedent to reactivate this representation. Thus, the aspect of anaphor functionality that involves the identification of the antecedent describes the role of the antecedent as a memory cue. As such, the semantic and phonological overlap between the anaphor and the memory representation of the antecedent affects the efficiency of the anaphor as a cue for memory activation—the greater the overlap, the better the cue.

The limited capacity of the working memory used in discourse processing also underlies the notion of anaphor’s processing cost. By most theories of word recognition, there is an initial stage in recognition where the meaning of a new word is activated independently of the previous discourse (Marslen-Wilson, 1987; Marsaro, 1989; Swinney, 1979). This entails that, at some stage in processing, both the meaning of the new word and the representation of the previous discourse are simultaneously active, at least until the representation of the new word is integrated with the discourse representation. It is assumed here that the underlying architecture of working memory affects semantic and discourse processing similarly to phonological processing. Specifically, just as increased phonological similarity decreases the capacity of working memory in phonological processing (Baddeley, 1992), it is assumed here that an increased semantic similarity between the representation of a new word and the discourse representation decreases the capacity of working memory in discourse processing. Furthermore, just as an increased amount of phonological information (e.g., longer words) adversely affects working memory capacity in phonological processing (Baddeley, 1992), increased semantic information (e.g., more specific expressions) reduces working memory capacity in discourse processing. Thus, the present notion of cost is based on the application of known properties of working memory in the domain of phonological processing—the amount of information and the amount of overlapping information—to the domain of discourse processing.

In summary, the architecture of the working memory resources that are used for discourse processing and, more specifically, the fact that these resources are used for both the maintenance of the discourse representation and for processing subsequent input underlies the cost-function optimization principle that, according to the ILH, describes anaphor processing. Indeed, if identifying the antecedent was the only consideration in anaphor processing, anaphors that provide maximal overlap with the representation of the antecedent would always be used. The reason this is not true is because although anaphors serve to reactivate information in working memory, their processing also requires working memory resources. Because working memory resources have a limited capacity, anaphors whose processing requires a big chunk of these resources would take away resources from other processes that use the same resources. Thus, always using the most effective reactivation cue would require in many cases computational resources that may be needed for other processing (e.g., maintaining active representation of other referents) and that may not be necessary for reactivating the representation of the intended referent (e.g., because it is already the most highly active referent; i.e., the discourse focus).

It should be noted here that the exact nature of verbal working memory is a matter of considerable debate, especially with respect to whether it is a single general resource that is shared by many language-processing subsystems (e.g., discourse processing vs. syntactic parsing; Just & Carpenter, 1992; Just, Carpenter, & Keller, 1996) or an array of separate resources that are not shared by different subsystems (e.g., Caplan & Waters, 1999; Waters & Caplan, 1996). Clearly, the implications of this debate may be relevant for anaphor processing; if working memory is a single resource that serves all linguistic processing, non-anaphor-related aspects of language, such as the syntactic complexity of the intervening material between an antecedent and the anaphor, will also affect the ease of processing an anaphoric expression. In contrast, if each linguistic subsystem has its own working-memory resources, the syntactic complexity of the intervening material should not play any role in anaphor processing. Although these differences clearly merit further investigation, they fall beyond the scope of the present work. For the present purpose, it is only necessary to note that by just about anyone’s theory, working memory has a limited capacity that is likely to impose restrictions such as the cost-justification principle expressed by the ILH. In other words, the restrictions expressed by the ILH can be traced to psychological constraints imposed by the structure of working memory.
Formalizing the Informational Load Hypothesis

The formalization of the ILH presented below represents an attempt to capture the relevant psychological mechanism in the most general formal framework possible, without subjecting the theory to any superfluous assumptions. Accordingly, the ILH is formulated as a series of high-level constraints and not as an implemented computational model. Although implementing a computational model of the ILH is certainly possible, deriving empirical predictions from a more general formalism provides a stronger test of the theory that is not confounded by the many assumptions necessitated by a computational implementation.

Recall that the notion of the informational load associated with an anaphor is devised to capture the intuition expressed in Ariel (1990) that referring expressions have different costs depending on their informativeness and to ground that intuition in cognitive terms, specifically in constraints imposed by working memory. Because the informativeness of a referring expression is dependent on what is already known, the informational load of an anaphor is defined with respect to its antecedent and is determined by the difference between the semantic representation of the anaphor and the semantic representation of the antecedent. The notion of C-difference is used as a formal link between the informational load of the anaphor-antecedent pair and the semantic distance between the anaphor and the antecedent. The following definition of the C-difference between an anaphor P and an antecedent N, \( CD(P, N) \), is illustrated in Figure 1.

Definition 1: C-difference

1. For an anaphor \( P \) that is more general than its antecedent \( N \) (bottom part of Figure 1), the C-difference between \( P \) and \( N \), \( CD(P, N) \), is negative and decreases (i.e., becomes more negative) with increasing semantic distance between \( N \) and \( P \), as is measured by typicality ratings or verification response times of "\( N \) is \( P \)" or "\( P \) is \( N \)" statements (Rips, Shoben, & Smith, 1973).
2. For an anaphor \( P \) less general than its antecedent \( N \) (top part in Figure 1), the C-difference between \( P \) and \( N \), \( CD(P, N) \), is positive and increases with increasing semantic distance between \( N \) and \( P \).
3. For an anaphor \( P \) equal to its antecedent \( N \) (a repetitive anaphor), the C-difference between \( P \) and \( N \), \( CD(P, N) \), is zero.

In Figure 1, the bottom part represents cases in which the anaphor is more general than its antecedent (negative C-difference), and the top part represents cases in which the anaphor is less general than its antecedent (positive C-difference). Because the C-difference between an anaphor and a less general antecedent is expressed as a negative value, this difference will be larger (i.e., less negative) with decreasing semantic distance. In contrast, because the C-difference between an anaphor and a more general antecedent is expressed as a positive value, this difference will be larger (i.e., more positive) with increasing semantic distance. The illustration in Figure 1 includes several examples of different anaphors co-referring with the antecedent a bird. The different anaphors differ in their level of specificity. Specificity is one factor that affects semantic distance (Rips et al., 1973) and, hence, C-difference. The semantic distance between creature and bird is smaller than the semantic distance between thing and bird. Therefore, as is evident in Figure 1, the C-difference between the anaphor the creature and the less general antecedent a bird is negative (bottom part) but is bigger (i.e., less negative) than the C-difference between the even more general anaphor the thing and the antecedent a bird. The C-difference between the repetitive anaphor the bird and the antecedent a bird is zero. The C-difference between the anaphor the robin and the more general antecedent a bird is positive but is smaller than the C-difference between the anaphor the crippled robin and the anaphor the bird (top part). Overall, as demonstrated in Figure 1, the C-difference between anaphor and antecedent increases with increase in the specificity of the anaphor: \( CD(\text{the thing, a bird}) < CD(\text{the creature, a bird}) < CD(\text{the bird, a bird}) < CD(\text{the robin, a bird}) < CD(\text{the crippled robin, a bird}) \).

It is important to note that C-difference is not claimed to have any autonomous psychological function. In fact, the notion of C-difference is superfluous from the perspective of the ILH because the definition of C-difference could have been incorporated directly into the definition of informational load below. C-difference is only used here as a separate notion for expository purposes. Having defined the notion of C-difference, I now use this notion to define informational load.

Definition 2: Informational Load

Informational load of an anaphor \( P \), given an antecedent \( N \), is a monotonic increasing function of the C-difference between the anaphor and the antecedent, \( CD(P, N) \), defined in Definition 1. More formally, the informational load is a function \( f \) of the C-difference...
between the anaphor and antecedent, \( \text{IL}(P, N) = f(\text{CD}(P, N)) \), such that for every two anaphor-antecedent pairs \( [(P_1, N_1), (P_2, N_2)] \), if the C-difference between the anaphor and antecedent in one pair is bigger than the C-difference between the anaphor and antecedent in the other pair (i.e., \( \text{CD}(P_1, N_1) > \text{CD}(P_2, N_2) \)), then the informational load of the pair with the bigger C-difference is higher than the informational load of the pair with the lower C-difference. The monotonic increasingness of informational load is summarized in Equation 1.

\[
\text{CD}(P_1, N_1) > \text{CD}(P_2, N_2) \rightarrow \text{IL}(P_1, N_1) > \text{IL}(P_2, N_2).
\] (1)

Although the choice of such a general formalization for the ILH enables the testing of the broad claims of the theory without introducing unnecessary assumptions, it also imposes two noticeable limitations. The first limitation stems from the fact that Definitions 1 and 2 do not provide a method of calculating the actual value of the informational load of a particular anaphor-antecedent pair. Therefore, on the basis of these definitions, it is impossible to compare the informational load of two antecedent-anaphor pairs in which both antecedent and anaphor are different (i.e., \( P_1 \neq P_2 \) and \( N_1 \neq N_2 \)). However, if either the antecedent or the anaphor is identical in the two antecedent–anaphor pairs (i.e., \( P_1 = P_2 \) or \( N_1 = N_2 \)), then it is possible, on the basis of the present formalization of the ILH, to make a clear, qualitative prediction about which of the two pairs will have a higher informational load. This is pursued in detail in the next section concerning the predictions of the ILH.

The second limitation is related to the circumstances under which the ILH can make a prediction about the effect of informational load on the ease of processing. In its present form, the ILH does not enable a systematic study of the differential effect of informational load on NP anaphors that add new information about their referent. This is because, presently, neither the amount of the new information added by the anaphor nor its informational load with respect to its antecedent are quantified. Because in cases like Example 2 below, these two factors may vary together (i.e., the informational load of the anaphor the ostrich is higher than the informational load of the anaphor the robin with respect to the antecedent a bird, but identifying the antecedent as an ostrich might add more new information about it than identifying it as a robin) and because according to the ILH, these two factors have opposite effects on the ease of processing (i.e., higher informational load may make the anaphor harder to process as long as the antecedent is identifiable, but more new information may make it easier to process because the high informational load would be functional), it is impossible to make a prediction about their combined effect on processing. Thus, the present formalization of the ILH cannot predict which anaphor—the one in Example 2a below or the one in Example 2b—is easier to process.

Example 2:

a. A bird ate the fruit. The ostrich seemed very satisfied.

b. A bird ate the fruit. The robin seemed very satisfied.

In sum, because the ILH attributes processing cost to the relation between the amount of new information added by the anaphor and its informational load with respect to its antecedent, it would be impossible to determine the processing cost without devising an accurate quantitative way to measure these two factors independently of each other. This limitation, however, does not prevent the ILH from making strong and testable predictions about cases in which it is clear that only one of the two factors (i.e., informational load or the amount of new information added by the anaphor) varies. In fact, by not committing the ILH to a particular quantification of new information and informational load, the predictions that are made by the theory have a broad scope that is not restricted to any particular view of new information and semantic representation.

**Empirical Predictions**

The ILH leads to four empirical predictions that are tested in the experiments described in this article. Before turning to these specific predictions, however, it is important to demonstrate how the ILH applies to some general cases of NP anaphors. Consider first the case of two anaphor–antecedent pairs that share the same antecedent \( N \) but have different anaphors \( P_1 \neq P_2 \). In this case, according to Definition 2 above,

\[
\text{CD}(P_1, N) > \text{CD}(P_2, N) \rightarrow \text{IL}(P_1, N) > \text{IL}(P_2, N).
\] (2)

Assume, with no loss of generality, that the anaphor \( P_1 \) is more specific than the anaphor \( P_2 \) (e.g., \( P_1 = \text{the robin}, P_2 = \text{the bird} \)). According to Definition 1, for any given antecedent \( N \), the more specific the semantic representation associated with an anaphoric expression \( P \) is, the higher is \( \text{CD}(P, N) \). Thus, in the present case, \( \text{CD}(P_1, N) > \text{CD}(P_2, N) \). Therefore, from Equation 2, \( \text{IL}(P_1, N) > \text{IL}(P_2, N) \). In other words, given an antecedent \( N \), the more specific the semantic representation associated with an anaphoric expression \( P \) co-refering with \( N \) is, the more informationally loaded the pair \( (P, N) \) is. For example, given the antecedent a robin, the informational load of the anaphor–antecedent pair \( (\text{a robin, the crippled robin}) \) would be higher than that of the pair \( (\text{a robin, the robin}) \), which in turn would be higher than that of the pair \( (\text{a robin, the bird}) \). This is illustrated schematically in the left part of Figure 2. Because the C-difference between the anaphor the robin and any antecedent is always bigger than the C-difference between the anaphor the bird and that same antecedent, it is true, by the definition of informational load, that for any given antecedent, the informational load of the anaphor the robin would be higher than the informational load of the anaphor the bird. Therefore, in Figure 2, the line representing the informational load of the anaphor the robin is higher than the line representing the informational load of the anaphor the bird.

Let us now turn to the case of two anaphor–antecedent pairs that share the same anaphor \( P \) but have different antecedents \( N_1 \neq N_2 \). According to Definition 2, a given anaphor can have a different informational load when co-refering with different antecedents:

\[
\text{CD}(P, N_1) > \text{CD}(P, N_2) \rightarrow \text{IL}(P, N_1) > \text{IL}(P, N_2).
\] (3)

One situation in which two anaphor–antecedent pairs with the same anaphor have different C-differences is when the anaphor is a category term and the two antecedents are instances of that category with varying degrees of typicality. Under the assumption that a term denoting an atypical category instance is more semantically distant from the category term than a term denoting a typical instance, and according to the definition of C-difference (Definition 1):

\[
\text{CD}(P, \text{typical antecedent}) > \text{CD}(P, \text{atypical antecedent}).
\] (4)
Therefore, according to Equation 3,

\[ \text{IL}(P, \text{typical antecedent}) > \text{IL}(P, \text{atypical antecedent}). \] (5)

For example, the anaphor–antecedent pair (the bird, a robin) would have a higher informational load than the anaphor–antecedent pair (the bird, an ostrich) because the C-difference between the anaphor the bird and the antecedent an ostrich is bigger than the C-difference between the anaphor the bird and the antecedent a robin. This is illustrated by the relation between the two parts in Figure 2: Because ostrich is further away from bird than robin is from bird, the informational load of the anaphor the bird is lower for the antecedent an ostrich than it is for the antecedent a bird.

In sum, the ILH claims that the ease of processing NP anaphors can be described by the interaction of three factors: discourse focus, the amount of new information added by the anaphor, and the informational load of the anaphor–antecedent pair. The ILH implies that if an anaphor does not add new information about its referent, then the smaller the informational load of the anaphor–antecedent pair, the easier it is to process as long as this informational load is sufficient for identifying the antecedent. This means that in cases in which the antecedent is focused and is, therefore, the “default” antecedent, an anaphor with high informational load with respect to that antecedent would be harder to process if it does not add any new information about its referent. This is precisely the case of repetitive anaphors. Although they have high informational load, they add no new information about their referent. Figure 3 shows a schematic representation of the implications of the ILH.

The theoretical implications of the ILH lead to the following specific empirical predictions:

**Prediction 1.** Anaphors with low informational load with respect to a particular antecedent (e.g., “A robin ate the fruit. The bird seemed very satisfied.”) are easier to process when that antecedent is focused than when it is not. This prediction follows directly from the assumption that the focused discourse entity is the default antecedent because it is strongly activated in working memory. This prediction is tested in Experiment 1.

**Prediction 2.** Anaphors with high informational load with respect to a particular antecedent and that add new information about their referent (e.g., “A bird ate the fruit. The robin seemed very satisfied.”) are easier to process when that antecedent is focused than when it is not. These anaphors satisfy the relevant conditions of the ILH and, therefore, are easier to process when their antecedent is focused. This prediction is tested in Experiment 2.

**Prediction 3.** Anaphors with high informational load with respect to a particular antecedent, which do not add new information about their antecedents (e.g., repetitive anaphors: “A bird ate the fruit. The bird seemed very satisfied.”), are easier to process when their antecedent is not focused than when it is. Only in the former case does the high informational load have a justification in aiding the identification of the antecedent—when the antecedent is focused, it is the default antecedent, and thus an anaphor with low informational load with respect to that antecedent would be sufficient for identifying that antecedent. This prediction is tested in Experiments 3 and 4.

**Prediction 4.** Given a focused antecedent and an anaphor that does not add new information, the more informationally loaded that anaphor is with respect to that antecedent, the harder it is to process. This is the account the ILH provides for the established finding that pronouns are best suited as anaphors to the focused discourse entity (e.g., “A bird ate the fruit. It seemed very satisfied.”). Pronouns carry only minimal information (i.e., gender and number) and, thus, when paired with any antecedent, form the least informationally loaded form of anaphor.

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4 Ease of processing is commonly thought of as a measure of discourse coherence. For example, van-Dijk and Kintsch (1983) viewed discourse coherence as reflecting the extent to which new discourse elements are easy to integrate into the discourse representation (for more details, see van-Dijk & Kintsch, 1983, chap. 5). Experimentally, ease of processing and coherence are commonly assessed by reading speed in self-paced reading tasks. This is also the methodology used here.
This prediction is not at all trivial, because it entails that the anaphor the bird would be easier to process when its focused antecedent is the ostrich (as in Example 3a) than when its focused antecedent is the robin (as in Example 3b).

Example 3:

a. An ostrich ate the fruit. The bird seemed very satisfied.
b. A robin ate the fruit. The bird seemed very satisfied.

As described earlier, the informational load of the anaphor the bird with respect to the antecedent a robin is higher than it is with respect to the antecedent an ostrich (see Figure 2). Because when the antecedent is focused, a high informational load has no functional justification (the anaphor does not add new information and its specificity does not aid identifying the antecedent that is anyhow the default one), the anaphor–antecedent pair (the bird, a robin) with the higher informational load should be harder to process than the anaphor–antecedent pair (the bird, an ostrich; see Figure 2). This is tested in Experiment 5.

Category-membership relation between antecedent and anaphor provides a straightforward way to test the predictions of the ILH for nonrepetitive NP anaphors (i.e., Predictions 1, 2, and 4). First, when the antecedent is the name of a category instance (as in Example 3), the category name would be an anaphor that does not add any new information and that has a relatively low informational load with respect to the category-instance antecedent (Prediction 1). In the inverse situation (i.e., category antecedent, instance anaphor; see Example 2), the category-instance anaphor would have a high informational load with respect to the category antecedent but would also add new information about the referent that, according to the ILH, should provide a functional justification for the high informational load (Prediction 2). Finally, by varying the typicality of the category instance, different degrees of informational load can be induced (Prediction 4).

Centering Theory, the Repeated-Name Penalty, and the Pronoun Constraint

The predictions of the ILH contradict one of the basic claims of Gordon, Grosz, and Gilliom (1993), who, on the basis of centering theory (Grosz et al., 1983), argued that an NP anaphor is always disfavored when its antecedent is focused. In contrast to centering theory, and especially to the psychological studies by Gordon and his colleagues (Gordon et al., 1993, p. 341; see also Gordon, 1993; Gordon & Chan, 1995; Gordon & Scearce, 1995), the ILH predicts that nonrepetitive anaphors will be processed faster when their antecedent is focused.

Gordon and his colleagues (Gordon, 1993; Gordon & Chan, 1995; Gordon et al., 1993; Gordon & Scearce, 1995) have used a paradigm that is based on a comparison between pronouns and repeated NP anaphors to explore which factors affect the salience ranking of discourse entities. Their paradigm is based entirely on a strict interpretation of the first rule of centering theory, namely that references to the discourse focus should be realized by a pronoun, as was originally proposed in Grosz et al. (1983). In the rest of this article, this interpretation is referred to as the pronoun constraint. Although the pronoun constraint is proposed as a soft constraint, in the sense that it can be violated, its violation should have some processing cost. Therefore, argued Gordon and his colleagues, if there is any additional cost involved in using an NP anaphor when referring to a particular discourse entity relative to others, this entity must be the discourse focus. Indeed, when Gordon et al. (1993) measured the reading times of sentences that referred back to the discourse focus with either a pronoun or a repeated proper name, they found that the repeated-name sentences were read slower than the pronoun sentences, an effect that they dubbed “the repeated-name penalty.” But, if violating the pronoun constraint is the explanation of the repeated-name penalty, as Gordon and his colleagues argued, then there should be a more general “definite-NP penalty” associated with referring to the discourse focus with a definite NP. In other words, the penalty should not be restricted to repetitive anaphors but should also accrue for definite-NP anaphors in general. However, if the repeated-name penalty is not an instance of a more general definite-NP penalty, then violating the pronoun constraint cannot account for the repeated-name penalty, at least not without adding another explanation for the absence of a more general penalty.

In Experiments 1 through 5, I not only tested the predictions of the ILH but also tested the validity of the pronoun constraint violation account of the repeated-name penalty. Whereas Experiments 3 and 4 tested the reading time of repetitive NP anaphors while manipulating the focal status of their antecedent, Experiments 1, 2, and 5 used the same paradigm but with nonrepetitive NP anaphors. If the repeated-name penalty is a consequence of violating the pronoun constraint, then a repeated-name penalty

\[5\] The extent to which centering theory itself claims that an NP anaphor is disfavored when referring to the focused discourse entity depends on its version. In its most recent formulation (Grosz et al., 1995), this claim has been omitted. However, this claim forms the basis for the methodology used in the psychological studies of centering theory done by Gordon and his collaborators.

\[6\] According to centering terminology, discourse focus is the most salient “forward-looking center,” and the reference to the discourse focus within any utterance is the “backward-looking center” of that utterance. In centering terms, the pronoun constraint would read: “The backward-looking center should be realized as a pronoun.” For simplicity’s sake, in the present discussion of centering theory I continue to use the terms focus and reference to the discourse focus.
should be observed in all the experiments. The pronoun constraint is equally violated by any NP anaphor regardless of its informational load with respect to its antecedent. In contrast, although the ILH also predicts a repeated-name penalty for the repeated anaphors in Experiments 3 and 4 (Prediction 3), it predicts that there should not be a repeated-name penalty for the nonrepeated anaphors in Experiments 1, 2, and 5 (Predictions 1, 2, and 4). This is because the ILH attributes the repeated-name penalty to the use of an NP anaphor with functionally unjustified high informational load (see Prediction 3).

**Experiment 1**

In the first experiment, I used a self-paced reading task to measure the effect of focus on the processing of NP anaphors that do not add new information about their referent and that have low informational load with respect to their antecedents. According to Prediction 1 of the ILH, these anaphors should be easier to process and, therefore, should be read faster when their antecedent is focused. Category membership was used for relating anaphors to their antecedents. A category anaphor co-refering with a category-instance antecedent adds no new information about the referent and has low informational load with respect to the category-instance antecedent (see Figure 2).

Focus was manipulated by using two kinds of clefts, it-cLEFTs and wh-cLEFTs (pseudo cLEFTs), which, with similar word order, impose a different focus—it-cLEFTs focus the first entity in the sentence, whereas wh-cLEFTs focus the second (see Example 4). This enables a direct assessment of the focus effect independently of linear word order. As is demonstrated in Example 4, both constructions can be used to focus an entity as having some property in contrast to other entities. In Example 4a, the robin is focused as the entity that has the property that it ate the fruit, whereas in Example 4b, the apple is focused as the entity that has the property that it was eaten by the robin.

Example 4:

a. It was the robin that ate the apple.

b. What the robin ate was the apple.

The psychological focusing of the clefted entity had been demonstrated in several psychological studies using a variety of paradigms (e.g., Birch, Albrecht, & Myers, 1995; Carpenter & Just, 1977; Clark & Clark, 1977, pp. 87-105). In particular, Birch et al. and Carpenter and Just showed that the clefted entity becomes the most salient entity (i.e., the discourse focus) following the cleft. To eliminate any focus biases that might have been introduced by leading discourse, all the items in the present experiment started with the clefted sentence. Although cLEFTs rarely occur discourse initially (Delin, 1995; Prince, 1978), the use of discourse initial cLEFTs was common to all conditions in this experiment and, thus, cannot explain differences in results between these conditions.

Ease of processing was assessed by measuring the reading time of the category-NP anaphor in the subject position of the sentence following the cLEFT. In two out of the four conditions in this experiment, the category anaphor co-refered with the first noun in the cLEFT (e.g., the bird was used for the sentences in Example 4), and in the other two conditions, the anaphor co-refered with the second noun in the cLEFT (e.g., the fruit was used for the sentences in Example 4). Overall, this design allows a comparison between the reading time of an anaphor when its antecedent is focused and the reading time of the same anaphor when its antecedent is unfocused, while controlling for linear word distance between the anaphor and the antecedent. To make sure participants read the text, and to gain a measure of their understanding, a yes-no question was added to each paragraph.

Table 1 shows an example of an item in all four conditions numbered from (i) to (iv). According to Prediction 1 of the ILH, anaphors with low informational load with respect to their antecedent should be read faster when that antecedent is focused. For the example in Table 1, the ILH predicts that the anaphor the bird in Sentence 2 in (iii) should be read slower than in Sentence 2 in (i) and the anaphor the fruit in Sentence 2 in (ii) slower than in Sentence 2 in (iv).

**Method**

**Materials.** Twenty short paragraphs similar in form to the one in Table 1 were constructed. First, a set of 40 category names was selected from the Battig and Montague (1969) norms to form 20 pairs of category...
terms that matched in word frequency (Francis & Kucera, 1982) and in polysemy count (on the basis of the Wordnet database; Miller, Beckwith, Fellbaum, Gross, & Miller, 1993). This was done to reduce differences between the two categories in general activation, and in how strongly they relate to the typical instance. For each pair of categories (e.g., bird and fruit), a pair of typical instances (Battig & Montague, 1969) was selected so that the two instances would match in word frequency (Francis & Kucera, 1982) and, roughly, in word length (e.g., robin and apple).

The two typical category-instance terms in each pair were embedded in a sentence that included a transitive verb subcategorizing for a noun phrase as a direct object (e.g., “the bird ate the fruit”). The verb was used in the active voice. Each of the resulting 20 sentences was transformed to both an i-cleft and a wh-cleft form (e.g., “it was the bird that ate the fruit” and “what the bird ate was the fruit”). Both kinds of clefts partition information into a focus component and a nonfocused, “presupposition” component (Delin, 1995; Prince, 1978). However, wh-clefts (but not it-clefts; see Prince, 1978, for details) must meet the requirement that their nonfocused component could be appropriately identifiable and accessible to readers. To satisfy this requirement, the NP in this part was definite (e.g., “what the bird ate”).

To maintain uniformity and provide a standard basis for comparison between the two NPs in each sentence, and between the two kinds of cleft constructions, both category terms were used in the definite form in both constructions. Although the somewhat unnatural introduction of new entities with definite NPs might cause some processing difficulties, there is no reason to expect that these difficulties would affect the four conditions differently. These sentences were used as the first sentences in the experimental items.

The subject of the second sentence was the category term of one of the category instances in the first sentence (e.g., bird or fruit). The rest of the second sentence was constructed to follow the subject naturally and was different for the two possible subjects. Each item ended with a yes–no question. Table 1 shows an example of a complete item in all four versions. The correct answer to half of the questions in each category was “yes” and to the other half “no.” To encourage participants to read the text for understanding, the answer to many questions was not clear-cut, although one answer was better than the other (e.g., “Elaine’s three children went to a party together. Elaine was upset because her older daughter was late. Was Elaine upset because her son did not return early?”). All participants indicated after the experiment that they believed that the point of the experiment was answering the questions.

The 20 experimental items were embedded in 40 distractor items, which were identical for all participants. The distractor items were similar to the experimental items in that they consisted of a leading sentence, a second sentence, and a yes–no question. The distractor items were not clefted. Not all the distractor items had an anaphor in the subject position of the second sentence. In those that had, the anaphoric expression was either a pronoun, a proper name, or a definite NP.

Design and procedure. The experiment was conducted using a self-paced reading paradigm. Each trial consisted of four fragments: a leading sentence, the subject of the second sentence, the rest of the second sentence, and a yes–no question pertaining to this item (see Table 1 for an example). Each trial was preceded by a fixation asterisk that appeared in the left side of the screen halfway down. After the participant pressed the scroll key, the focus asterisk disappeared and the first fragment of text was displayed starting from the previous location of the asterisk. All the fragments were displayed starting from the same initial location. Participants were instructed to read the text at a normal speed and answer the questions as accurately and as rapidly as they could. One shift key was used for scrolling the text and for responding affirmatively to the questions and the other shift key for responding negatively. Participants used their dominant hand to scroll the text and respond positively.

The time lapse from the presentation of each text fragment and the participant’s pressing on a key was recorded as well as the response the participant gave for the question. The dependent variable in this experiment was the reading time of the anaphoric subject of the second sentence, that is, the time lapse from the onset of the presentation of the anaphor until the participant pressed the scroll key (see Table 1). This ensured that reading times reflected the effort involved in processing the anaphor per se as opposed to the effort involved in processing the whole sentence in which it was embedded. The anaphor was always the second fragment to be presented. To maintain uniformity in the experiment, the second sentence of the distractor items was also divided into subject and predicate, which were presented separately.

The experiment had four conditions (2 syntactic constructions X 2 antecedent positions). The first independent variable was the syntactic construction in the first sentence, that is, the form of cleft that defines what is the focused category instance. This variable had two levels: wh and it. The second independent variable was the antecedent position—which of the category instances in the first sentence was a member of the category appearing in the subject of the second sentence. This variable had two levels: first and second.

Each item appeared in each of the four conditions, but each participant saw only one version of each item. Overall, each participant saw 20 experimental items, 5 of each condition. The assignment of items to conditions per participant was randomized so that within a group of 4 consecutive participants, each item appeared in all four conditions. The order of presentation of the 60 items was individually randomized for each participant.

Prior to reading the block with the 20 experimental items and 40 distractor items, participants read a practice block containing 20 practice items. Participants who finished the practice block with at least 90% correct answers proceeded into the experimental block. Participants who were less than 90% correct during the practice block went through it again until they reached or passed the 90% criterion. No participant was eliminated from the study on the basis of his or her performance on the practice trials.

Two items had to be excluded from the analysis because of technical problems in their presentation (it was discovered after the experiment was completed that these two items were presented to all participants in only one condition). The results of several pilot studies indicated that values of more than two standard deviations away from the mean of each condition calculated across all participants should be deleted. This cutoff criterion was applied uniformly in analyzing the results from all the experiments reported in this article. In all of the experiments, the removed values were randomly distributed among all the conditions and did not conform to any pattern. In this experiment, 5% of the data were affected. Because the purpose of including questions at the end of each item was to keep the participants alert and to encourage them to read and process the materials in general, there was no exclusion of data from an individual item to which a participant responded incorrectly. However, all the data from a participant were excluded if that participant did not answer at least 80% of the questions correctly. Because all the participants in this experiment answered more than 85% of the questions correctly, no data from any participant were excluded.

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7 Definiteness is clearly not the only way to satisfy the restriction that the unfocused part in a wh-cleft contains information that is accessible to the reader. For example, the following wh-cleft, “what we’ve done so far is introduce the background and the theory,” could be used in a text like the present article because the phrase “we’ve done so far” refers to the material covered in the article up to the present point and can therefore be assumed to be very accessible to readers. Definiteness, however, is the only way to satisfy the accessibility restriction for the single-noun NPs that were used in the present experiment.

8 The materials used in all the experiments reported in this article are available on request from Amit Almor.
Apparatus. The materials were presented on a Macintosh II 14-in. screen in a 14-point bold Geneva font. The participants used the left and right shift keys of the keyboard to scroll the text and to answer the yes-no questions. Participants used the index finger of their dominant hand to scroll the text and indicate a positive answer to the questions and the index finger of their nondominant hand to indicate a negative answer to the questions. The software used for running the experiment recorded responses with an accuracy of ±1 ms.

Participants. Twenty-eight Brown University undergraduate and graduate students were paid $5 for participating in this study. All participants were native speakers of English and were naive about the goals of the experiment.

Results and Discussion

The mean reading times of anaphors in all conditions are shown in Table 2. A 2 × 2 analysis of variance (ANOVA) of Construction Type (it vs. wh) × Antecedent Position (first vs. second) was conducted separately for participants as the random factor, and for items as the random factor. The results revealed no main effect of either syntactic construction, F1, F2 < 1, or antecedent position, F1, F2 < 1, in all cases. However, the interaction was significant by participants, F1(1, 27) = 8.28, p < .008, and marginally significant by items, F2(1, 34) = 3.33, p < .08. The NP anaphors were read 31 ms faster on average when their antecedents were focused than when they were not.

With the exception that the item analysis was not significant at the conventional .05 level, these results confirmed the first prediction of the ILH. When the anaphor was the more general term, thus having a low informational load with respect to its antecedent and not adding new information about the referent, focus facilitated processing.

Experiment 2

Experiment 2 was undertaken to test the second prediction of the ILH, namely that anaphors that have a high informational load but add new information about their antecedent, are easier to process when their antecedent is focused. Anaphors that are more specific than their antecedents (i.e., “It was the bird that ate the apple. The robin seemed very satisfied.”) have a high informational load with respect to their antecedent and also add new information about their referent. However, anaphors that are subordinate terms of their antecedent, such as the ones used in Experiment 2, do add new information. When reading the phrases “It was the bird that ate the apple. The robin seemed very satisfied.”, the reader has no way of knowing which kind of bird is referred to by the NP the bird before reading the anaphor the robin. If adding new information about the referent was the only crucial factor governing reading times in the present paradigm, Experiments 1 and 2 should have yielded a different pattern of results. Because both experiments yielded the same pattern of results, the data cannot be attributed either to the presence or absence of new information.

Although the results so far are consistent with the ILH, they are also consistent with a much simpler explanation, namely that anaphors are simply read faster when their antecedent is focused. The purpose of Experiments 3 and 4 was to test the ILH in the more diagnostic cases in which the ILH predicts that anaphors will be read more slowly when their antecedent is focused.

Table 2

Reading Times of Category Anaphors With Category-Instance Antecedents Under Different Focus Conditions in Experiment 1

<table>
<thead>
<tr>
<th>Construction</th>
<th>Antecedent position</th>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>It-cleft</td>
<td></td>
<td>443</td>
<td>481</td>
</tr>
<tr>
<td>Wh-cleft</td>
<td></td>
<td>468</td>
<td>444</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>25</td>
<td>-37</td>
</tr>
</tbody>
</table>

Note. The underlined numbers are the reading times of the anaphors with focused antecedents. The differences in the bottom row reflect differences between the reading times of the same word when preceded by different focus-manipulating constructions.
between the anaphor and the antecedent). As was shown by the results of Experiment 2, when an anaphor from this class adds new information, it has a functional justification even when its antecedent is focused, and, therefore, the only effect of focus in this case is to speed up the referent identification. In contrast, when an anaphor from this class (i.e., with a high informational load) does not add any new information, the high informational load may have a functional justification only when the referent is not focused. In this case, the informational load of the anaphor may facilitate the referent identification. On the other hand, when the referent is focused, it is the default antecedent and, therefore, the extra informational load serves no function. This is the rationale behind Prediction 3 of the ILH, which states that anaphors that have a high informational load with respect to their antecedent and do not add new information about their referent should be read more slowly when their antecedent is focused than when it is not. Repetitive anaphors represent the prototypical case of this category of anaphors and were used to test Prediction 3 of the ILH.

Consider Example 5 below. If the ILH is correct, then in this case, focus should yield an effect opposite to the focus effect found in the previous experiments—the anaphor the bird should be read slower in Example 5a than in Example 5b, and the anaphor the fruit slower in Example 5d than in Example 5c.

Example 5:

a. It was the bird that ate the fruit.
   The bird seemed very satisfied.

b. What the bird ate was the fruit.
   The bird seemed very satisfied.

c. It was the bird that ate the fruit.
   The fruit was already half rotten.

d. What the bird ate was the fruit.
   The fruit was already half rotten.

Method

The same materials from Experiments 1 and 2 were used with the anaphor and antecedent both set to the category name (as in Example 5). Again, the same methodology was used with 28 different participants who were recruited from the same population.

Reading times of more than two standard deviations away from the mean of each condition were deleted (affecting 4% of the data). The data from 2 participants were excluded because these participants performed below the 80% correct criterion.

Results and Discussion

The mean reading times of the anaphors are listed in Table 4. As in the previous experiments, a $2 \times 2$ ANOVA of Construction Type (it vs. wh) X Antecedent Position (first vs. second) revealed no main effect of syntactic construction, $F_1, F_2 < 1$. Although anaphors referring to the first noun were read 17 ms faster than anaphors referring to the second noun, the antecedent position did not have a significant effect on reading times, $F_1(1, 25) = 2.99, p < .12$. However, there was a significant interaction effect by participants, $F_1(1, 25) = 6.80, p < .02$, and marginally significant by items, $F_2(1, 38) = 3.11, p < .09$.— anaphors were read 23 ms slower on average when their antecedents were focused than when they were not.

With the exception that the item analysis was not at the standard .05 significance level (the fact that a similar result was observed and found significant in Experiment 4 below lends credence to making this exception), this result is compatible with Prediction 3 of the ILH. In line with Prediction 3 of the ILH, the direction of the interaction effect was exactly the opposite of that observed in Experiments 1 and 2: Repetitive anaphors were read more slowly when their antecedent was in focus. The fact that the effect found in the present experiment was opposite to the effect found in Experiments 1 and 2 shows that the effects found in all these experiments are not due to the introduction of new discourse entities in definite form, because this was common to the materials used in all the experiments.

In addition to supporting the ILH, this finding is compatible with previous research, which demonstrated a repeated-name penalty, namely that repeated NP anaphors are read slower than pronouns when referring to the discourse focus (Gordon et al., 1993). In fact, the results of Experiment 3 extend this previous finding by showing that a repeated-name penalty is also exhibited by the difference in the reading times of the same NP anaphor under different focus conditions: A repeated-NP anaphor is read slower when its antecedent is focused than when its antecedent is not focused. Taken together, the results from the first 3 experiments do not support the previous explanation of the repeated-name penalty, which states that the use of a definite-NP anaphor deprives readers of the important focus-continuity cue provided by the use of a pronoun (e.g., Gordon, 1993). The present results suggest that it is not the deprivation of the pronoun cue that causes the slower reading times for repetitive anaphors when they refer to a focused antecedent. That effect exists only for repetitive ana-

Table 3

Reading Times of Category-Instance Anaphors With Category Antecedents Under Different Focus Conditions in Experiment 2

<table>
<thead>
<tr>
<th>Construction</th>
<th>Antecedent position</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
<td></td>
</tr>
<tr>
<td>It-cleft</td>
<td>453</td>
<td>468</td>
<td></td>
</tr>
<tr>
<td>Wh-cleft</td>
<td>483</td>
<td>430</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>30</td>
<td>-38</td>
<td></td>
</tr>
</tbody>
</table>

Note. The underlined numbers are the reading times of the anaphors with focused antecedents. The differences in the bottom row reflect differences between the reading times of the same word when preceded by different focus-manipulating constructions.

Table 4

Reading Times of Repetitive Anaphors Under Different Focus Conditions in Experiment 3

<table>
<thead>
<tr>
<th>Construction</th>
<th>Antecedent position</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
<td></td>
</tr>
<tr>
<td>It-cleft</td>
<td>415</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>Wh-cleft</td>
<td>403</td>
<td>443</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>-12</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Note. The underlined numbers are the reading times of the anaphors with focused antecedents. The differences in the bottom row reflect differences between the reading times of the same word when preceded by different focus-manipulating constructions.
phors but not for other definite-NP anaphors, which also deprive readers of the pronoun cue. Thus, it is evident that, in line with the ILH, the factor that is responsible for the slower response times is directly associated with repetition itself.

**Experiment 4**

All the experiments described so far used materials that violated the presuppositions of the definite article. Because the antecedent was definite, the readers had to infer that there was a contextually unique entity with whose identity they were expected to be familiar. It might seem reasonable to argue that at least some of the effects in the previous experiments were related to strategies that participants had to use to establish the definite reference in the focus-manipulating sentence.

There is yet another related phenomenon that should be addressed here. Clefled constructions can generate a contrast set (Chafe, 1976), sometimes also called an alternative set (Lambneider, 1987). For example, in a scenario in which a bird and a cat are in a room, the sentence “It was the bird that ate the fruit” might in fact focus the cat as the contrast entity of the bird. In other words, discourse focus might shift not to the entry mentioned in the cleft (i.e., the bird) but instead to the entry not mentioned in the cleft (i.e., the cat). Thus, it might be argued that the effect of these constructions is the focusing of the other members of the contrast set of the clefted entity. Effects associated with contrast sets have been previously studied and shown to arise in cases of implicit negation associated with quantification (Clark, 1974; Just & Carpenter, 1971; Moxey & Sanford, 1993) and contrastive stress (Sedivy, Carlson, & Tanenhaus, 1994). In the present context, it might be that the repeated-name penalty effect in Experiment 3 was due to a focus shift from the entity to the contrast set and did not result from the repetition itself. Obviously, in this case, a different explanation would be required for the effects shown in Experiments 1 and 2. However, because this argument raises the possibility that the repeated-name penalty observed in the last experiment might have been linked to an idiosyncratic property of the materials used, it was tested explicitly.

Experiment 4 was designed to replicate the results of Experiment 3 using materials that do not violate the presuppositions of the definite article and to test whether a repeated-name penalty is associated with facilitation of contrast set references. Consider the following two paragraph beginnings:

Example 6:

a. A man and a girl were walking a dog and a parrot.
   It was the girl that walked the parrot.
   What the girl walked was the parrot.

b. A man and a girl were walking a dog and a parrot.
   What the girl walked was the parrot.

Neither paragraph violates the presuppositions of the definite article, and both paragraphs can be followed by a sentence starting with an NP anaphor referring to one of the four entities mentioned in the first sentence. Table 5 shows an example of all eight possible paragraphs indexed from (i) to (viii). Both the ILH and the contrast-set explanation predict that the repetitive anaphor the girl would be read slower when its antecedent is focused (i) than when it is not (ii) and, similarly, that the repetitive anaphor the parrot would be read slower in (iv) than in (iii). Such outcome would further support the ILH and show that this repeated-name penalty cannot be attributed to violating the presuppositions of the definite article.

Furthermore, if the contrast-set argument in the form described above is correct in attributing the repeated-name penalty to an activation of a contrast set, then the NP anaphor the man, which is the contrast term of the NP the girl should be read faster when the

<table>
<thead>
<tr>
<th>Antecedent set position</th>
<th>It-cleft (focus on first category)</th>
<th>Wh-cleft (focus on the second category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>(i) A man and a girl were walking a dog and a parrot. $</td>
<td>(ii) A man and a girl were walking a dog and a parrot. $</td>
</tr>
<tr>
<td></td>
<td>It was the girl that walked the parrot. $</td>
<td>What the girl walked was the parrot. $</td>
</tr>
<tr>
<td></td>
<td>The girl $ was too small to walk the dog. $</td>
<td>The girl $ was too small to walk the dog. $</td>
</tr>
<tr>
<td>Second</td>
<td>(iii) A man and a girl were walking a dog and a parrot. $</td>
<td>(iv) A man and a girl were walking a dog and a parrot. $</td>
</tr>
<tr>
<td></td>
<td>It was the girl that walked the parrot. $</td>
<td>What the girl walked was the parrot. $</td>
</tr>
<tr>
<td></td>
<td>The parrot $ was small enough for the girl to carry. $</td>
<td>The parrot $ was small enough for the girl to carry. $</td>
</tr>
<tr>
<td>First</td>
<td>(v) A man and a girl were walking a dog and a parrot. $</td>
<td>(vi) A man and a girl were walking a dog and a parrot. $</td>
</tr>
<tr>
<td></td>
<td>It was the girl that walked the parrot. $</td>
<td>What the girl walked was the parrot. $</td>
</tr>
<tr>
<td></td>
<td>The man $ was strong enough to walk the big dog. $</td>
<td>The man $ was strong enough to walk the big dog. $</td>
</tr>
<tr>
<td>Second</td>
<td>(vii) A man and a girl were walking a dog and a parrot. $</td>
<td>(viii) A man and a girl were walking a dog and a parrot. $</td>
</tr>
<tr>
<td></td>
<td>It was the girl that walked the parrot. $</td>
<td>What the girl walked was the parrot. $</td>
</tr>
<tr>
<td></td>
<td>The dog $ was too big for the small girl to walk. $</td>
<td>The dog $ was too big for the small girl to walk. $</td>
</tr>
</tbody>
</table>

Note. The $s mark fragment boundaries. Each fragment was presented separately on the screen. Not presented in this table is the yes–no question that was added to make sure participants read the text and to assess their understanding.
girl is in focus, as in (v), than when it is not, as in (vi). Similarly, the dog should be read faster when the parrot is in focus, as in (viii), than when it is not, as in (vii).

Method

Twenty-four experimental items similar in form to the ones in Table 5 were constructed. A leading sentence introduced two pairs of indefinite NPs connected by a transitive verb. It was followed by a cleft sentence (either a wh-cleft or an it-cleft), which used the same or a very closely related verb to connect between one member of the first set and one member of the second set. The two nouns were referred to by repeated anaphors. The subject of the third and last sentence was one of the four nouns introduced in the leading sentence and was presented separately. Each of the four different nouns was followed by a different ending so as to make the paragraph coherent. All items were followed by a yes–no question.

The experiment had eight conditions: 2 sets (first, second) × 2 anaphor types (repeated, contrast) × 2 syntactic constructions (it, wh). The first independent variable was whether the target noun in the subject of the third sentence was a member of the first or second set in the first sentence. For the sample item in Table 5, the first set is \{man, girl\} and the second is \{parrot, dog\}. The second variable was whether this noun was a repetition of a noun mentioned in the second sentence (e.g., girl or dog) or its contrast term from the first sentence (e.g., man and parrot). Finally, the third variable was the syntactic construction of the second sentence.

There were 64 distractor items. All the distractor items were of similar form in that they consisted of three sentences and a question. About one third of the distractor items referred to more than two entities so that the experimental items would not stand out.

The methodology of the previous experiments was used, with the exception that each item consisted of three sentences instead of two. Forty new participants were recruited from the same population.

Reading times more than two standard deviations away from the mean of each condition were deleted (affecting 6% of the data). No data from any participant had to be excluded from the analysis, because all participants performed above the 80% correct criterion.

Results and Discussion

The mean reading times of the anaphors are listed in Table 6. As in the previous experiments, a 2 × 2 × 2 ANOVA of Construction Type (it vs. wh) × Antecedent Set Position (first vs. second) × Anaphor Type (repetitive vs. contrast) revealed no main effect for either construction type or antecedent position, \(F_{1}, F_{2} < 1\). Although contrast anaphors were read faster than repeated anaphors, the effect of anaphor type was not statistically significant, \(F_{1}(1, 39) = 1.35, p < .26; F_{2}(1, 46) = 1.45, p < .24\). However, as in the previous experiments, there was a significant interaction effect between the construction type and antecedent position, \(F_{1}(1, 39) = 4.71, p < .04; F_{2}(1, 46) = 7.61, p < .008\). Anaphors referring to the focused noun and to its contrast term were read 23.5 ms slower on average than anaphors referring to the nonfocused noun and its contrast term. There were no other significant interactions, \(F_{1}, F_{2} < 1\). Most notably, because the three-way interaction was not significant, there was no support for the contrast set account for the repeated-name penalty. In fact, the contrast anaphors were also read slower when their paired terms were focused, although a planned comparison contrasting means (v) and (viii) against means (vi) and (vii) indicated that this difference was not reliable in and for itself, \(F < 1\). Thus, contrary to the prediction of the contrast-set argument, the penalty for repeated anaphors was not associated with facilitation of contrast anaphors.

A planned comparison contrasting the means of the repetitive-anaphor conditions—(i) and (iv) against (ii) and (iii)—confirmed that the repeated anaphors were read significantly slower when their antecedents were focused than when they were not, \(F_{1}(1, 32) = 4.33, p < .05; F_{2}(1, 40) = 6.84, p < .03\). This finding replicates and extends the results of Experiment 3 in showing that the repeated-name penalty is not restricted to cases that violate the presuppositions of the definite article.

Although the findings described so far provide support for the general predictions of the ILH, they do not support the notion of informational load directly. Specifically, it may seem that the repeated-name penalty can be explained as an idiosyncrasy of repetitive anaphors that is unrelated to informational load. Fortunately, Prediction 4 of the ILH most crucially depends on the notion of informational load and, thus, enables a direct evaluation of its importance. The next experiment tested Prediction 4.

Experiment 5

Prediction 4 of the ILH states that the reading speed of anaphors is related to the C-difference between the anaphor and the antecedent—the more general an anaphor is with respect to its focused antecedent, the faster will it be read (see Figures 1 and 2). This implies that a given NP anaphor co-referring with a more specific antecedent that is focused will be read faster the more semantically distant it is from that antecedent. In other words, in the case of an antecedent more specific than the anaphor, and when that antecedent is focused, the more specific that antecedent is, the faster will the anaphor be read. This is because, according to the ILH, when the antecedent is focused and when the anaphor does not add any new information about the referent, the less informationally loaded the anaphor–antecedent pair is, the easier the anaphor is to process (see Figure 3). Consider the following examples below:

Example 7: a. The professor and her student arranged the transportation for their field trip. It was the student that rented the car. The vehicle was necessary for getting to the exploration site.
b. The professor and her student arranged the transportation for their field trip. It was the student that rented the boat. The vehicle was necessary for getting to the exploration site.

c. The professor and her student arranged the transportation for their field trip. What the student rented was the car. The vehicle was necessary for getting to the exploration site.

d. The professor and her student arranged the transportation for their field trip. What the student rented was the boat. The vehicle was necessary for getting to the exploration site.

The second sentences in Examples 7c and 7d focus the car and the boat respectively, but in Examples 7a and 7b, they focus the student. The ILH yields the following three predictions.

(i) The anaphor the vehicle should be read faster in Example 7d than in Example 7c for the following reason: A boat (as in Example 7d) is a less typical instance of the categories vehicle and car (as in Example 7c), and, thus, the semantic distance between boat and vehicle is bigger than the semantic distance between car and vehicle. Because the anaphor the vehicle is more general than both antecedents, the C-difference between the anaphor the vehicle and the antecedent the boat is smaller (i.e., more negative) than the C-difference between the anaphor the vehicle and the antecedent the car (Definition 1). Therefore, the anaphor-antecedent pair in Example 7d (the vehicle, the boat) is less informationally loaded than the pair in Example 7c (the vehicle, the car). Because in Example 7d and Example 7c the antecedent is focused, the ILH entails that the anaphor in the less informationally loaded pair (in Example 7d) should be read faster (Prediction 4).

(ii) The anaphor the vehicle should be read faster in Example 7c than in Example 7a and faster in Example 7d than in Example 7b. This is because in all cases the anaphor does not add any new information about its referent and has a low informational load and, thus, according to Prediction 1 of the ILH, should be read faster when its antecedent is focused. The antecedent is focused only in Example 7c and Example 7d, and, therefore, the anaphor in these two cases should be read faster than in the other two cases.

(iii) The anaphor the vehicle will be read faster in Example 7a than in Example 7b because in both cases the antecedent is not focused, and, therefore, the anaphor's function of identifying the antecedent becomes more important. Because terms denoting typical category instances are easier to match with the category term than terms denoting atypical instances, the term the car (as in Example 7a), which denotes a more typical instance of the vehicles category than the one denoted by the term the boat (as in Example 7b), would be easier to match with the category term the vehicle. This would lead to the predicted faster reading of the anaphor the vehicle in Example 7a than in Example 7b. The current experiment used materials similar to Example 7 to test these predictions.

Method

Materials. Twenty-four experimental items similar in form to the one in Example 7 were constructed. First, a set of 24 categories was selected from the Battig and Montague (1969) typicality norms. For each category, the norms were used to select a pair of instances, one typical and one atypical, such that the two instances would match in word frequency (Francis & Kucera, 1982) and, roughly, in word length (e.g., boat and car).

Each item started with a leading sentence, which introduced two conjoined entities that were involved in some activity together (e.g., "The professor and her student arranged the transportation for their field trip."). Conjoined entities were used to allow a more natural use of clefting as a means of specifying some fact pertaining to only one of the conjoined entities. In all cases, the two entities were related by a possessive article (as the article her in the previous example). The focus manipulation was introduced in the second sentence, which was a cleft sentence (either an it-cleft or a wh-cleft) that specified for one of the entities from the leading sentence how it was involved in the action described (e.g., "It was the student that rented the boat," and "What the student rented was the boat."). In half of the items, this was the first entity in the leading sentence, and in the other half it was the second. This entity was always the surface subject of the second sentence. The second entity in the clefted sentence was one of the two category instances, the typical or atypical, and was introduced in a definite form (e.g., the car and the boat). The contexts were constructed so that the category used in each item would be plausible in that context, or even suggested by it.

The subject of the third sentence was the category term of the category instance in the second sentence. The rest of the third sentence was constructed to follow the subject naturally. As in the previous experiments, each item ended with a yes-no question. The four paragraphs a–d in Example 7 provide an example for an item in all four conditions.

The 24 experimental items were embedded in 48 distractor items, which were identical for all participants. The distractor items were similar to the experimental items in that they consisted of three sentences and a yes-no question.

Design and procedure. The same design and procedure were used as in the previous experiments, with the exception that now each item consisted of three sentences instead of two. The participants were 28 different paid volunteers who were recruited from the same population.

For the analysis, reading times more than two standard deviations away from the mean of each condition were deleted (affecting 5% of the data). The data from 1 participant were excluded from further analysis because of failure to meet the 80% correct criterion.

Results

The mean reading times of the anaphors are listed in Table 7. A 2 × 2 ANOVA of Construction Type (it vs. wh) × Antecedent Typicality (typical vs. atypical) revealed no main effects for either typicality, F1, F2 < 1, or focus, F1(1, 26) = 1.79, p < .2; F2(1, 23) = 1.78, p < .2. However, as expected, a significant interaction effect was obtained, F1(1, 26) = 8.92, p < .006; F2(1, 23) = 8.33, p < .008. The results were in most part consistent with the predictions of the ILH for this experiment, which were individually tested in a set of planned comparisons:

<table>
<thead>
<tr>
<th>Table 7 Reading Times of Category Anaphors With Typical and Atypical Antecedents Under Different Focus Conditions in Experiment 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>It-cleft (antecedent out of focus)</td>
</tr>
<tr>
<td>Wh-cleft (antecedent in focus)</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
</tr>
</tbody>
</table>
Prediction (i) was supported by the results. The category anaphor was read 25 ms faster on average when the antecedent was a focused atypical instance than when it was a focused typical instance, which is a reliable difference, \( F_1(1, 26) = 5.40, p < .03; \ F_2(1, 23) = 4.56, p < .05 \). This shows that when referring to the focused antecedent, the ease of establishing reference increases with increasing C-difference.

One part of Prediction (ii) (the comparison between Example 7b and Example 7d) was supported by the reading times of the anaphors with atypical antecedents. Those anaphors were read 38 ms faster on average when their antecedent was a significant difference, \( F_1(1, 26) = 11.53, p < .01; \ F_2(1, 23) = 9.42, p < .01 \). The other part of Prediction (ii) (the comparison between Example 7a and Example 7c) was not supported by the results. Category anaphors with typical antecedents were read 9 ms slower when their antecedents were focused than when they were not. However, this difference was not significant, \( F_1 < 1, F_2 = 1.03 \).

Prediction (iii) was only supported by the trend of the reading times of the anaphors with unfocused antecedents. Those anaphors were read 22 ms faster on average when their antecedent was a typical instance than when it was an atypical one. However, this difference was only marginally significant, \( F_1(1, 26) = 5.40, p < .07; \ F_2(1, 23) = 4.56, p < .07 \).

Discussion

The basic prediction of the ILH was supported. Among anaphors with a focused antecedent, anaphors with an atypical antecedent were the fastest to be read. The bigger the C-difference between the anaphor and the less general antecedent was, the easier it was to process. This result seems inconsistent with some previous research that showed an opposite effect, namely that category anaphors are read faster when their antecedents are typical than when they are atypical (Garnham, 1989; Sanford et al., 1977). However, in none of their experiments was focus directly manipulated. It is possible that in the contexts used in these previous experiments, the discourse entity of interest was not a salient discourse focus, as in the present experiment, thus leading to an effect similar to the effect observed in the unfocused conditions in the current experiment (i.e., typical unfocused read faster than atypical unfocused). Also, all of these previous results were based on reading times of whole sentences as opposed to only the anaphors. It is possible that on the completion of a sentence, participants construct an integrated representation of the entire sentence (e.g., McKoon & Ratcliff, 1992). Measuring the reading times of the anaphors without the following text provides a better measure of the effort it takes to resolve the reference of the anaphors independently of the text they are followed by.

The only prediction of the ILH that was not borne out by these results is the second part of Prediction (ii), the comparison between Example 7a and Example 7c. When the category anaphor had a typical instance antecedent, it was not read faster when that typical antecedent was focused than when it was not focused. This lack of focus effect might be due to an overriding effect of the higher C-difference between antecedents and anaphors in the typical conditions. It might be that this C-difference was so high (i.e., negative but close to zero) that it made these cases similar to repetitive anaphors, which are characterized by a zero C-difference from their antecedents. Whether this post hoc explanation is viable is an issue that is left for future research.

However, because this last post hoc explanation rests on the assumption that C-difference, being a product of semantic representation, can be modulated by context and because there is other evidence showing that certain kinds of discourse context can modify the family resemblance structure of a category in a manner that affects anaphor reading times (Roth & Shoben, 1983), it was important to verify that all the other effects obtained in this experiment were due to a genuine typicality difference between the typical and atypical conditions and were not due to some idiosyncrasies of the contexts used in each item. To this end, typicality norms in context were collected for the materials used in the reading experiment. Six native English-speaking graduate students volunteered to rate the typicality of the category instances in the contexts used in the experiment on a scale of 1 to 7, with 1 being highly atypical and 7 being highly typical. For 22 out of the 24 items that were used, the typicality ratings in context agreed on which category instance was the more typical one, with the Battig and Montague (1969) norms used to construct the materials. An ANOVA done on the ratings of the 22 items with typicality (typical vs. atypical) as a fixed factor revealed that the typical and atypical sets were highly distinguishable even in the contexts used, \( F_1(1, 6) = 207.20, p < .001; F_2(1, 21) = 89.50, p < .001 \), with the typical items having a mean rating of 4.83 and the atypical items 1.85.

Because the raters disagreed about the typicality rating of the remaining two items, a second ANOVA was performed on the results of Experiment 5, excluding the data of the two controversial items. This ANOVA yielded results that were identical to the first one in that only the interaction effect was significant and the direction of the effects was the same. This assured that the results of Experiment 5 were due to a true typicality difference between the typical and atypical conditions.

General Discussion

The findings of this study support the predictions of the ILH, a psychologically motivated account of NP anaphor use. In line with the Gricean maxim of quantity and with plausible assumptions about the architecture of the working-memory resources underlying discourse processing, the ILH associates the cost of processing an anaphor with a measure of informational load that is related to the semantic distance between the antecedent and the anaphor. According to the ILH, the use of an anaphor with a high informational load with respect to its antecedent is justified only when it adds new information to the discourse representation, or when it helps to identify the antecedent.

There are three major findings reported in this study, all of which support the ILH. First is the repeated-name penalty: Repeated NP anaphors are read slower when their antecedent is focused than when it is not focused (Experiments 3 and 4). The ILH attributes the repeated-name penalty to the use of an anaphor that has a high informational load with no functional justification. Repetitive anaphors do not add new information, and, thus, their high informational load is only justified when they help identify the antecedent. Because the focused discourse entity is the default antecedent, the high informational load of a repetitive anaphor is better justified when its antecedent is unfocused.
The second finding is that nonrepetitive NP anaphors are read faster when their antecedent is focused than when it is not focused (Experiments 1 and 2). The ILH states that anaphors with low informational load (Experiment 1), or high informational load that add new information (Experiment 2), are easier to process when their antecedent is focused.

The third finding is the inverse typicality effect: NP anaphors which are more general than their focused antecedent were faster to read the more semantically distant they were from their antecedent (Experiment 5). The ILH states that for anaphors with a focused antecedent, the less informationally loaded they are with respect to that antecedent, the easier they are to process. Thus, a category anaphor is less informationally loaded when its antecedent is an atypical instance of the category than when it is a typical instance (see Definitions 1 and 2).

In addition to supporting the predictions of the ILH, the present findings show that several previous studies (Cloitre & Bever, 1988; Gordon, 1993; Gordon & Chan, 1995; Gordon et al., 1993; Gordon & Scearce, 1995) were incorrect in generalizing results based on repeating anaphors to claims pertaining to the entire class of all anaphors. In particular, the work reported in a series of studies done by Gordon and collaborators was based on the assumption that the repeated-name penalty is a consequence of not using a pronoun to refer to the most salient discourse entity and, thus, depriving readers of an important cue. However, if depriving readers of the pronoun cue is the explanation of the repeated-name penalty, as Gordon argued, then there should be a more general definite-NP penalty associated with referring to the discourse focus with a definite NP. In other words, according to this line of reasoning, the penalty should not be restricted to repetitive anaphors but should also accrue for definite NP anaphors in general. The experiments reported here show that this is not the case. A repeated definite NP was not observed in cases where, according to Gordon, a pronoun should have been used. As shown by Experiments 1, 2, 3, and 4, the repeated-name penalty is a consequence of the repetition itself and not of the reader’s deprivation of the pronoun cue. It happens when using a repetitive anaphor but not when using a nonrepetitive NP anaphor, both of which equally deprive the reader of the pronoun cue.

More generally, these findings show that it is theoretically unjustified to group all NP anaphors in one category, which is to be contrasted with pronouns, and it is methodologically unwarranted to use results obtained with repetitive NP anaphors to support claims pertaining to the entire class of NP anaphors. In particular, these results undermine the common claim that a pronoun is always better than an NP anaphor as a form of reference to the discourse focus. The empirical motivation for this claim is based entirely on a comparison between pronouns and repetitive NP anaphors. It is a tenet of the current work that this comparison is invalid because anaphor use is not a matter of matching arbitrary forms to different situations but, like most other psychological processes, follows certain principles involving cost and function. The general preference for pronouns as means of reference to focused entities falls out of this principle and does not constitute an independent principle in and of itself. Quite obviously, pronouns have very low informational load (i.e., cost) with respect to any antecedent. Therefore, in certain contexts such as the task-oriented dialogues used by Grosz (1981), where the main function of referring expressions is to establish successful reference, pronouns would be preferable for referring to the discourse focus. However, in other contexts, such as literary or expository texts, referring expressions may also serve to add new information, which should make definite NP anaphors more likely to be used.

The contrast between the high informational load repetitive anaphors, which are read slower when their antecedent is focused, and low informational load nonrepetitive anaphors, which are read faster when their antecedent is focused, suggests a new psychological paradigm for exploring the focusing effects of linguistic devices other than clefting. For a linguistic construction to be regarded as focusing a certain entity, it must exhibit two properties. First, repetitive anaphors co-referring with that entity as an antecedent should be read slower when that entity is embedded in this construction than when it is not. Second, nonrepetitive NP anaphors co-referring with that entity as an antecedent should be read faster when that entity is embedded in this construction than when it is not. This provides a two-way test that can be applied even when using a pronoun is impossible (as in the case of contrast terms like those in Experiment 4 above).

Other Research

One important aspect of the ILH that was discussed earlier but not tested directly is its applicability to pronouns. Given any antecedent, a pronoun should be the least informationally loaded, nonelliptical anaphor. Therefore, according to the ILH (as well as many other accounts), it should be the most appropriate anaphoric form for referring to the discourse focus. The ILH views pronouns and NP anaphors not as two separate and unrelated categories but as two different parts of a continuum of anaphoric expressions, a continuum spreading from the least informationally loaded pronouns to the highly informationally loaded, definite NP anaphors. This idea is compatible with much theoretical work in linguistics (e.g., Ariel, 1990; Chafe, 1994; Gundel et al., 1993), which attributes the appropriate specificity of a referring expression, as well as the choice of an appropriate determiner (i.e., a, the, this, that) to the degree to which its referent is accessible in the discourse representation.

Further evidence supporting the applicability of the ILH to pronouns comes from recent research about the production and comprehension of anaphoric reference in patients with Alzheimer’s disease (AD), which have a working memory impairment (Almor, Kempler, MacDonald, Andersen, & Tyler, 1999). This research demonstrated that while these patients make excessive use of pronouns, they also have a serious pronoun-comprehension impairment. Using a cross-modal naming methodology, in which participants have to read a target word presented on a computer screen at the offset of an auditory context, Almor et al. found that:

1. AD patients were less sensitive than age-matched healthy control participants to violations of number and gender agreement between pronouns and their antecedents, as in the following (mismatching pronoun is capitalized): “The children loved the silly clown at the party. During the performance, the clown threw candy to HIM.”

2. AD patients were faster to name an adjective that modified an antecedent when reference was maintained through repetitive NP anaphors rather than through pronouns (e.g., the capitalized target is read faster in “The housewife watched the clumsy plumber working under the sink. The housewife showed the
plumber where the leak was. The housewife could not believe that the plumber was so CLUMSY” than in “The housewife watched the clumsy plumber working under the sink. She showed him where the leak was. She could not believe that he was so CLUMSY’”). In contrast, age-matched normal controls showed exactly the opposite pattern: They were faster to name the adjective when reference was maintained through pronouns than through NP anaphors. Thus, although healthy elderly persons performed more poorly with repeated NP anaphors than with pronouns similarly to the repeated-name penalty, AD patients performed better with repeated NP anaphors, showing a repeated-NP advantage.

3. The tendency to produce pronouns, the sensitivity to the appropriateness of pronouns, and the extent to which adjectives were named faster in the NP anaphor contexts than in the pronoun contexts were all correlated with performance in a working memory task. The higher participants scored on the working memory task, the less likely they were to produce pronouns, the more sensitive they were to the appropriateness of pronouns, and the faster they were to name the adjective in the pronoun contexts than in the NP contexts.

Thus, although the production of AD patients is characterized by an abnormally frequent use of pronouns, their ability to comprehend pronouns is significantly compromised, and they are better able to access information about the referent when an NP anaphor is used. Furthermore, AD patients’ referential impairments in both comprehension and production are linked to working memory performance.

The ILH provides a ready explanation for these findings. In comprehension, the working memory impairment in AD leads to an overall decrease in the activation of referents, therefore enabling costly referring expressions (full NPs vs. pronouns) to attain more functionality for AD patients than for healthy participants. Thus, although repetitive NP anaphors are normally more costly and indeed may hinder comprehension in healthy people, they may nevertheless serve a special function for AD comprehenders. For AD comprehenders, these NP anaphors provide significant facilitation in identifying and reactivating the representation of the referent in working memory. In other words, the overall degraded working memory representation in AD leads to an overall decrease in discourse activation, thus enabling costly referring expressions to attain more functionality in AD comprehension by aiding the identification of the antecedent.

In production, AD patients’ representation of referents in working memory is degraded, leading to the loss of some distinguishing semantic features (e.g., Martin, 1987; Tippett, McAuliffe, & Farah, 1995). For example, the representation of robin might become more similar to the representation of bird. According to the ILH, this loss of specific information about the referent causes an increase in the processing cost of all possible anaphors. This is because, according to the ILH, cost is a matter of the semantic relation between the representations of the anaphor and the referent, and not only the anaphor representation itself. For example, although the expression the bird has only little processing cost with respect to the referent the robin, it has a higher processing cost with respect to the referent the bird (because of the greater amount of repeatedly activated semantic features in the latter case than in the former). Therefore, when semantic detail is lost in a referent’s representation, a more general and less costly anaphor, such as a pronoun, is likely to be produced. Thus, according to the ILH, the overall degraded working memory representation of referents in AD leads to an overall increase in the processing cost of all anaphors, thus rendering the more general (i.e., less informative) expressions more likely to be produced.

The evidence from the AD research complements the evidence presented here in showing that the same principle of cost and function, which is associated with the use of working memory resources, describes the processing of both pronominal and NP anaphors. When cost or function changes, as in the case of AD patients, the processing of referential expressions changes accordingly. The findings of the Almor et al. (1999) study, and in particular the correlation between reference processing and performance in a working memory task, also support the notion that cost is related to constraints imposed by the architecture of working memory.

Conclusion

The present study provides a link between theoretical pragmatics notions, such as new information and focus, and the psychological issues involved in the use and processing of NP anaphors. The appeal to a general pragmatic principle—the balance of computational cost, and discourse function—distinguishes the ILH from previous accounts of NP anaphor processing (e.g., Gordon et al., 1993; Grosz, Joshi, & Weinstein, 1995), which are based on the assumption that phenomena of the kind described in this research can only be explained by domain-specific principles (e.g., the pronoun constraint). However, unlike purely pragmatic theories (e.g., Ariel, 1990; Sperber & Wilson, 1986, 1995), which propose similar principles that are based on cost and function, the ILH grounds its notions of cost and function in the architecture of the underlying memory system. Overall, this work shows that the combination of linguistic function and cognitive principles could constitute the basis for a psychological explanation of an important aspect of language use.

References


**NOUN-PHRASE ANAPHORA AND FOCUS**

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