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**Noun-Phrase Anaphora and Focus:  
The Informational Load Hypothesis**

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## ABSTRACT

The processing of NP anaphors in discourse is argued to be grounded in cognitive representation and communicative principles. Derived from the Griceian maxim of quantity, the proposed theory views NP anaphor processing as an optimization process based on the principle that processing cost, defined in terms of conceptual representation, should serve some discourse function -- identifying the antecedent and/or adding new information. 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 conceptual 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 cost.

The observation that not all components of a linguistic message share the same informational status underlies several decades of research on pragmatics. Whereas some components are included in a message as a means of connecting it to the representation of previous discourse, other components contain new information that functions to supplement or modify this representation. The two kinds of components are commonly referred to as the “given” or “topic” component, and the “new” or “comment” component, respectively (Prince, 1981; see Valduvi, 1993, for a detailed review). Because the information about the relevant entities is added incrementally during discourse, often in separate utterances, these entities have to be referred to repeatedly. Reference to previously mentioned discourse entities can be established through the use of noun-anaphors, that is, expressions that do not pick a real-world referent directly but only through co-referentiality with an antecedent that has been previously introduced into the discourse. Noun-anaphors can take one of several forms -- fully specified definite descriptions like the dog (henceforth NP anaphors), proper names like Fido, demonstratives like that dog, pronominal anaphors like he and it (henceforth pronouns), or null anaphors<sup>1</sup>. Much effort has been devoted to characterize the circumstances in which one form of reference is preferable to another (e.g. Ariel, 1990; Gordon, Grosz, & Gilliom, 1993). As argued by many authors (Ariel, 1990; Garrod & Sanford, 1984; Gernsbacher, 1989; Gordon, et al., 1993; Grosz, Joshi, & Weinstein, 1983; Gundel, Hedberg, & Zacharski, 1993; van-Dijk & Kintsch, 1983), the form of linguistic expression best suited for establishing a reference depends primarily on the current discourse focus. Because the term “focus” is often used to describe different concepts in the literature, it is important to note that in the present paper, the term focus is used to describe the most active and salient entity in the discourse representation and not the new information component of a single utterance.

It is generally acknowledged that discourse focus affects the processing of anaphoric expressions because anaphors require a matching process for identifying the antecedent, a process that is sensitive to the relative salience of the various entities in the discourse (cf. Sanford &

Garrod, 1981; van-Dijk & Kintsch, 1983; Ariel, 1990). This 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 (Givon, 1987; Ariel, 1990). For example, based on cross-linguistic text analysis, Ariel (1990) offers a universal Accessibility Scale which is an ordering of all the different classes of referring expressions according to how accessible their antecedent is at the point of reference. Two points on Ariel's accessibility scale are of interest here. On the high end of the scale, unstressed pronouns are almost always used to refer to the most accessible (i.e., salient) discourse entity. On the lower end of the scale, definite NP anaphors are most frequently used to access less salient 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. van-Dijk & Kintsch, 1983; Gordon, Grosz, & Gilliom, 1993; Gordon & Scearce, 1995; Grosz, Joshi, & Weinstein, 1983) and is supported by distributional analysis (Ariel, 1990; Grosz, 1981) and experimental evidence (Gordon, et al., 1993).

Despite the usefulness of the accessibility scale, the psychological processes that underlie the use of anaphoric expressions remain poorly understood. The common view (e.g., Ariel, 1990; Gordon, Grosz, & Gilliom, 1993; Grosz, Joshi, & Weinstein, 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 identify referents. Ariel (1990) makes the important observation that, in general, the more salient the referent is, the less information is contained in the anaphoric expression. To explain this inverse relation between anaphor informativeness and referent accessibility, Ariel (1990) associates different processing costs with the different forms of reference -- definite NP anaphors have a high processing cost because they evoke a more detailed representation whereas pronouns have a smaller processing cost because they evoke a very general representation containing only number

and gender features. Establishing 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 sufficiently informative referring expression that may have a higher cost.

The present study takes this idea one step further in that it argues that the psychological processes underlying anaphor use are governed by the following general principle: Additional cost must serve some additional discourse function. The present notions of cost and function are broader than the ones suggested by Ariel (1990) -- cost is a matter of conceptual representation and not merely of anaphoric form, and discourse function is not only identifying the referent but possibly also adding new information. This principle distinguishes not only between anaphors of different kinds (i.e., pronouns and NP anaphors) but also between anaphors of the same kind that differ in their cost or discourse function.

To illustrate this last point, consider the difference between repetitive and non repetitive NP anaphors. Repetitive anaphors are just what their name implies. They consist of a determiner (the definite article in the cases examined in the current work) and the same common noun as their antecedent, as in Example 1a. Non-repetitive anaphors, on the other hand, consist of an expression which is not identical to the antecedent, but which is sufficiently informative to identify the antecedent in the given context (Example 1b and 1c). In Example 1b, the non-repetitive NP anaphor ‘the wet little bird’ adds the new information that the robin seemed little and wet, and also that the speaker is emphatic towards that robin. Under the present view, the addition of new information is an important discourse function that justifies the use of a referring expression with a relatively high cost. This is the intuition behind the claim made in this work that the addition of new information may license the use of an anaphor with high cost (the notion of cost is explained later in the paper). Example 1c represents another class of non-repetitive anaphors that are more general than their antecedents and are therefore ‘less costly’ than repetitive anaphors. In Example 1c, the non-repetitive NP anaphor is used just to establish reference without adding any new

information. As will be explained in more detail later, the current view distinguishes between the three cases in Example 1, and predicts that the repetitive NP anaphor in Example 1a will be processed with the greatest difficulty because it fares worst in terms of cost and function -- it has a relatively high cost that serves no discourse function.

### 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.

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 which 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, Grosz, & Gilliom, 1993; Gordon & Scearce, 1995) were based on a comparison between pronouns and repetitive NP anaphors, while overlooking the possibility that non-repetitive NP anaphors interact with discourse focus differently than repetitive ones by virtue of serving a different function or having a different processing cost.

The incorrect assumption that all NP anaphors are processed alike may be attributed to the common belief that the new information which may be added by non-repetitive anaphors interferes with processing in some irrelevant way. For example, Cloitre & Bever (1988), who studied the difference between pronouns and NP anaphors in the level of the discourse representation they access, 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, pp. 298). Similarly, in a

series of studies done by Gordon and his collaborators (Gordon, 1993; Gordon & Chan, 1995; Gordon, Grosz, & Gilliom, 1993; Gordon & Scearce, 1995), repetitive proper-name anaphors were compared to pronouns in many experiments geared at contrasting pronouns with NP and proper name anaphors in general.

In the following sections it is argued there is no a-priori reason to assume that the new information added by some non-repetitive anaphors is irrelevant to, and independent of, NP anaphor processing in general. On the contrary, it is shown that new information and discourse focus affect the processing of NP anaphors together in a completely predictable way. The proposed theory provides a unified, pragmatically, and above all experimentally motivated account of NP anaphor processing that applies to all kinds of NP anaphors.

### **The Informational Load Hypothesis (ILH)**

The proposed theory, the “informational load hypothesis” (henceforth ILH), is based on a pragmatic principle derived from the Gricean maxim of quantity. The Gricean maxim of quantity states that speakers should make their contribution as informative as required but not more than required. In other words, speakers should use the least complex linguistic form which is sufficiently informative for their communicative purpose. The ILH applies this principle to anaphoric expressions with the following two additions. First, complexity is expressed by the measure of “informational load” (which is defined below). Second, the informativeness of an anaphoric expression is divided into information that is required for identifying the antecedent, and information that is included as new information about the referent. The ILH is defined as follows:<sup>2</sup>

**Definition 1:** The informational load hypothesis (ILH)

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 or adding new information about it, or both.

The amount of information required for identifying the antecedent depends on whether that antecedent is focused or not. A focused antecedent is the most accessible antecedent, and therefore requires only little information to be identified. Thus, according to the ILH, discourse focus affects the choice of anaphoric expression because it modulates the ease of identifying the antecedent and therefore the amount of information required for identifying that antecedent. The degree to which an anaphor and antecedent pair respect the principle described by the ILH corresponds to how easy it is to process the anaphor. The ILH therefore attributes the ease of processing NP anaphors to the interaction of three factors -- discourse focus, the amount of new information conveyed by the anaphor, and the informational load of the anaphor/antecedent combination; the latter is defined immediately below.

**Informational load:** The informational load associated with an anaphor is a notion devised to capture the intuition expressed in Ariel (1990) that referring expressions have different costs depending on their informativeness, and ground that intuition in cognitive terms. 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 conceptual representation of the anaphor and the conceptual representation of the antecedent. To accomplish that, the notion of C-difference<sup>3</sup> is introduced as a formal link between the informational load of the anaphor/antecedent pair and the semantic distance between the anaphor and the antecedent. 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”. C-difference is only presented here as a separate notion to simplify the exposition of the ILH. The following definition of the C-difference between an anaphor P and an antecedent N,  $CD(P, N)$  is illustrated in Figure 1.

**Definition 2:** C-difference

1. For an anaphor P 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 bigger (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 bigger (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 which affects semantic

distance (Rips, Shoben, & Smith, 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.<sup>4</sup> 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 red 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:  $CD(\text{the thing, a bird}) < CD(\text{the creature, a bird}) < CD(\text{the bird, a bird}) < CD(\text{the robin, a bird}) < CD(\text{the red robin, a bird})$ .

Having defined the notion of C-difference, we can now utilize this notion to define “informational-load”.

**Definition 3:** 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 2 below. More formally, the informational load is a function  $f$  of the C-difference between the anaphor and antecedent,  $IL(P, N) = f(CD(P, N))$ , 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.  $CD(P_1, N_1) > CD(P_2, N_2)$ ) 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 Formula 1.

$$CD(P_1, N_1) > CD(P_2, N_2) \Rightarrow IL(P_1, N_1) > IL(P_2, N_2) \quad (1)$$

**The Scope of the ILH:** In its current formulation, the scope of the ILH is restricted by two noticeable limitations. The first limitation stems from the fact that Definitions 2 and 3 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 one of the antecedent or the anaphor is the same 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 definition 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 about 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 which 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 in Example 2, 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, in its present form, the ILH cannot not make any prediction about which anaphor, the one in Example 2a or the one in Example 2b, is easier to process. 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, informational load and the amount of new information added by the anaphor, varies.

### **Example 2**

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

**The Predictions of the ILH:** Let us 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 3:

$$CD(P_1, N) > CD(P_2, N) \Rightarrow IL(P_1, N) > IL(P_2, N) \quad (2)$$

Let us 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 2, for any given antecedent N, the more specific the conceptual representation associated with an anaphoric expression P is, the higher is  $CD(P, N)$ . Thus, in the present case:  $CD(P_1, N) > CD(P_2, N)$ . Therefore, from Formula 2:  $IL(P_1, N) > IL(P_2, N)$ . In other words, given an antecedent N, the more specific is the conceptual representation associated with an anaphoric expression P co-referring with N, the more informationally loaded is the pair (P, N). For example, given the antecedent a robin, the informational load of the anaphor/antecedent pair (a robin, the crippled robin) would be higher than that of the pair (a robin, the robin) which in turn would be higher than that of the pair (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 3, a given anaphor can have a different informational load when co-referring with different antecedents:

$$CD(P, N_1) > CD(P, N_2) \Rightarrow IL(P, N_1) > IL(P, N_2) \quad (3)$$

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 member is more semantically distant from the category term than a term denoting a typical member, and according to the definition of C-difference (Definition 2):

$$CD(P, \text{typical-antecedent}) > CD(P, \text{atypical-antecedent}) \quad (4)$$

Therefore, according to Formula 3:

$$IL(P, \text{typical-antecedent}) > IL(P, \text{atypical-antecedent}) \quad (5)$$

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 is affected 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<sup>5</sup> 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 claims of the ILH lead to the following empirical predictions:

### **Prediction 1**

Anaphors with low informational load with respect to a particular antecedent (Example 1c) 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 kept 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 (Example 1b), 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, that do not add new information about their antecedents (like repetitive anaphors; Example 1a), 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 (as in Example 3). 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.

#### **Example 3**

A robin ate the fruit. It seemed very satisfied.

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 4a) than when its focused antecedent is the robin (as in Example 4b). 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 ostrich (see Figure 2). Because when the antecedent is focused, a high informational load has no functional justification (it does not add new information and it does not aid identifying the antecedent which 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.

**Example 4**

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

Category membership relation between antecedent and anaphor provides a straight-forward way to test the predictions of the ILH for non repetitive NP anaphors (i.e. Predictions 1, 2, and 4). First, when the antecedent is the name of a category member (as in Example 4), 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-member antecedent (Prediction 1). In the inverse situation (category-antecedent, member-anaphor; see Example 2), the category-member anaphor would have a high informational load with respect to the category antecedent but would also add new information about the referent which, according to the ILH, should provide a functional justification for the high informational load (Prediction 2). Finally, by varying the typicality of the category member, 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 et al. (1993) who, on the basis of centering theory (Grosz, Joshi, & Weinstein, 1983), argued that an NP anaphor is always disfavored when its antecedent is focused. In contrast to centering theory<sup>6</sup>, and especially to the psychological studies by Gordon and his collaborators (Gordon, 1993; Gordon & Chan, 1995; Gordon, et al., 1993; Gordon & Scearce, 1995), the ILH predicts that non-repetitive anaphors will be processed faster when their antecedent is focused.

Gordon and his collaborators (Gordon, 1993; Gordon & Chan, 1995; Gordon, et al., 1993; Gordon & Scearce, 1995) have used a paradigm 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 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 the current paper this interpretation will be referred to as the “pronoun constraint”<sup>7</sup>. 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 et al., 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. Because in all their experiments Gordon et al. used repetitive proper-name anaphors, they dubbed the additional processing time of those anaphors as “the repeated-name penalty”.

Unfortunately, the empirical evidence for the claim that a pronoun is better than an NP anaphor as a form of reference to the focused discourse entity is based entirely on a comparison between pronouns and repetitive NP anaphors. This is a problem at both the theoretical and methodological levels. 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. If violating the pronoun constraint is the explanation of the repetition penalty, as Gordon and his collaborators argue, 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 repetition penalty is not an instance of a more general definite NP penalty, then violating the pronoun constraint cannot account for the repetition penalty, at least not without adding another explanation for the absence of a more general penalty.

Experiments 1 through 5 below not only test the predictions of the ILH but also test the validity of the pronoun constraint violation account of the repetition penalty. Whereas Experiments 4 and 5 test the reading time of repetitive NP anaphors while manipulating the focal status of their antecedent, Experiments 1, 2, and 3 use the same paradigm, but with non repetitive

NP anaphors. If the repetition penalty is a consequence of violating the pronoun constraint then a repetition penalty 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 repetition penalty for the repeated anaphors in Experiments 4 and 5 (Prediction 4), it predicts that there should not be a repetition penalty for the non-repeated anaphors in Experiments 1, 2, and 3 (Predictions 1, 2, and 3). This is because the ILH attributes the repetition penalty to a pragmatically inappropriate use of an NP anaphor with functionally unjustified high informational load (see Prediction 4).

## **EXPERIMENT 1**

The first experiment used a self-paced reading task to measure the effect of focus on the processing of NP anaphors which do not add new information about their referent and which 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-referring with a category-member antecedent adds no new information about the referent, and has low informational load with respect to the category-member antecedent (see Figure 2).

Focus was manipulated by using two kinds of clefts, *it*-clefts and *wh*-pseudo-clefts, which could license similar word order and have the same grammatical subject but impose different focus (see Example 5). This enables a direct assessment of the focus effect independently of grammatical subjecthood and linear word-order. Although the two constructions are not equivalent in their pragmatics in that *wh*-pseudo clefts require that the part conveying the “given” information would have already been mentioned in the discourse (Prince, 1978), the two

constructions can serve a similar pragmatic purpose with respect to “new” information. As is demonstrated in Example 5, both constructions can be used to focus an entity as having some property in contrast to other entities. In Example 5a, the robin is focused as the entity which has the property that it ate the fruit, whereas in Example 5b the apple is focused as the entity which has the property that it was eaten by the robin.

### Example 5

- 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 (cf. Birch, Albrecht, & Myers, 1995; Carpenter & Just, 1977; Clark & Clark, 1977, pp. 87-105). In particular, both Birch et al. (1995) and Carpenter & Just (1977) showed that the clefted entity becomes the discourse focus following the cleft.

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. 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 forty category names was selected from the Battig & Montague (1969) norms to form twenty pairs of category terms that matched in word frequency (Francis & Kucera, 1982) and in polysemy count (based on 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 member. For each pair of categories (e.g. bird and fruit), a pair of typical members (Battig & Montague, 1969) was selected so that the two members 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 which 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 twenty sentences was transformed to both an it-cleft and a wh-pseudo-cleft form (e.g. “it was the bird that ate the fruit” and, “what the bird ate was the fruit”). Because the “given” part in wh-pseudo-clefts cannot be completely new (as opposed to it-clefts; see Prince (1978) for details), the noun appearing in this part had to be in definite form. To maintain uniformity and provide a standard basis for comparison between the two nouns in each sentence, and between the two kinds of clefted constructions, both category terms were used in the definite form in both constructions. Although the somewhat unnatural introduction of new entities in definite form 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 twenty experimental items were embedded in forty 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 noun.

**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 which appeared in the left side of the screen half way 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 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 broken into subject and verb phrase parts 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 which defines which is the focused category exemplar. 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 twenty experimental items, five of each condition. The assignment of items to conditions per participant was randomized so that within a group of four consecutive participants, each item appeared in all four conditions. The order of presentation of the sixty 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 due to 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). For the analysis of the anaphor reading time, values more than 2 standard deviations away from the mean of each condition calculated across all participants were deleted (affecting 5.35% of the data). Because the purpose of including questions at the end of each item was to keep the subjects 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.

**Apparatus:** The materials were presented on a MAC II 14" 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 non dominant hand to indicate a negative answer to the questions. The software used for running the experiment recorded responses with an accuracy of  $\pm 1$  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 2x2 ANOVA, Construction Type (it vs. wh) x 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,  $F_1, F_2 < 1$ , or antecedent position,  $F_1, F_2 < 1$ , in all cases. However, the interaction was significant by participants,  $F_1(1,27) = 8.28, p < .008$ , and marginally significant by items,  $F_2(1,34) = 3.33, p < .08$ . 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 items 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 which have a high informational load, but add new information about their antecedent, are easier to process when their antecedent is focused. Anaphors which are more specific than their antecedents (as in “It was the bird that ate the apple. The robin seemed very satisfied”) have a high informational load with respect to their antecedent but also add new information about their referent. Therefore, by the second prediction of the ILH, they should be read faster when their antecedent is focused. Although in most cases, anaphors that are more specific than their antecedents read less naturally, and indeed have been shown to be processed more slowly than anaphors that are more general than their antecedents (Garnham, 1989; Sanford, Garrod, & Boyle, 1977; Sanford & Garrod, 1981), they still constitute a possible anaphoric form.

## Method

The same materials from Experiment 1 were used with the anaphor and antecedent switched so that the category term was now the antecedent and the instance term the anaphor (e.g. “It was the bird that ate the apple. The robin seemed very satisfied”). The same methodology was used with 28 different participants, recruited from the same population.

Reading times more than 2 standard deviations away from the mean of each condition were deleted (affecting 3.75% of the data.) Because all the participants in this experiment answered more than 88% of the questions correctly, no data were excluded on the basis of the correct response criterion.

## Results and Discussion

Table 3 shows the mean reading times of the anaphor in the four conditions. A 2x2 analysis of variance on the anaphor reading time, Construction Type (it vs. wh) x Antecedent Position (first vs. second), yielded no significant main effect of either syntactic construction,  $F_1, F_2 < 1$ , or antecedent position,  $F_1(1,27) = 1.77, p < .2$  ;  $F_2(1,38) = 1.53, p < .23$ . As in the previous experiment, there was a significant interaction effect,  $F_1(1,27) = 11.49, p < .002$  ;  $F_2(1,38) = 5.41, p < .03$ , with anaphors read 34 ms faster on average when their antecedents were focused than when they were not.

The results of Experiments 1 and 2 are consistent with Predictions 1 and 2 of the ILH. Taken together, these results rule out the possibility that the present results are related to only the presence or absence of new information in the anaphoric expression. Anaphors that are a superordinate term of their antecedent, like those used in Experiment 1, do not provide the reader with new information about their referent. However, anaphors which are subordinate terms of their antecedent, such as the ones used in Experiment 2, do add new information. When reading the paragraph: “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, Experiment 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 the following two experiments was to test the ILH in the more diagnostic cases in which it predicts that anaphors will be read more slowly when their antecedent is focused.

### **EXPERIMENT 3**

Consider the class of anaphors that have a high informational load with respect to their antecedent (i.e. a high C-difference 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 is 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 6 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 6a than in Example 6b, and the anaphor The fruit slower in Example 6d than in Example 6c.

### Example 6

- 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 6). Again, the same methodology was used with 28 different participants that were recruited from the same population.

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

## Results and Discussion

The mean reading times of the anaphors is listed in Table 4. As in the previous experiments, a 2x2 ANOVA, Construction Type (it vs. wh) by 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,  $F_1(1,25) = 2.99, p < .1$  ;  $F_2(1,38) = 2.56, p < .12$ . 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 0.05 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 “repetition penalty”, namely that repeated NP anaphors are read slower than pronouns when referring to the discourse focus (Gordon, Grosz, & Gilliom, 1993). In fact, the results of Experiment 3 extend this previous finding by showing that a repetition 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 three experiments speak against the previous explanation of the repetition penalty, which is that the use of a definite NP anaphor deprives readers of the important focus-continuity cue provided by the use of a pronoun (cf. 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 anaphors 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 which is responsible for the slower response times is directly associated with repetition itself.

## **EXPERIMENT 4**

All the experiments described so far used materials which violate the presuppositions of the definite article. Because the antecedent was introduced in definite form, the readers had to infer that there was some particular entity, whose identity they were expected to presuppose. It might seem reasonable to argue that at least some of the effects in the previous experiments were related to strategies participants had to use to establish the definite reference in the focus manipulating sentence.

There is yet another related phenomenon which should be addressed here. Clefted constructions can generate a contrast set (Chafe, 1976), sometimes also called an alternative set (Linebarger, 1987). For example, in a scenario where there are a bird and a cat in a room, the sentence “it was the bird that ate the fruit” might in fact foreground the cat. 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 focusing effect of these constructions is in fact the foregrounding of the contrast set of the focused entity. Effects associated with contrast sets have been previously studied and shown to arise in cases of negation

(MacDonald & Just, 1989), implicit negation associated with quantification (Clark, 1974; Just & Carpenter, 1971; Moxey & Sanford, 1993), and contrastive stress (Sedivey, Carlson, & Tanenhaus, 1994). In the present context, it might be that the repetition 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 repetition 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 repetition penalty is associated with facilitation of contrast set references.

Consider the following two paragraph beginnings:

### Example 7

- a. A man and a girl were walking a dog and a parrot.

It was the girl that walked 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 explanations predict that the repetitive anaphor the girl would be read slower when its antecedent is focused (i) than when it is not (ii). Similarly, the repetitive anaphor the parrot would be read slower in (iv) than in (iii). If this turns

out to be the case then it would provide further support to the ILH and show that this repetition penalty cannot be attributed to a violation of the definite article presuppositions.

Furthermore, if the contrast set argument in the form described above is correct in attributing the repetition 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 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

**Materials:** Twenty four experimental items similar in form to the one in Table 6 were constructed. A leading sentence introduced two pairs of indefinite nouns connected by a transitive verb. It was followed by a cleft sentence (either a wh pseudo-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) x 2 anaphor types (repeated, contrast) x 2 syntactic constructions (it, wh)). Table 5 shows an example of an item in all eight conditions. 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 example, in paragraph (2) 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.

Sixty-four distractor items were constructed. All the distractor items were of similar form in that they consisted of three sentences and a question. About one third of them 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 2 standard deviations away from the mean of each condition were deleted (affecting 5.59% 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 2x2x2 ANOVA, Construction Type (it vs. wh), by Antecedent Set Position (first vs. second), by 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 non-focused 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 is no support for the contrast set account for the repetition 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 repetition penalty is not restricted to cases which 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 repetition 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 its utility. The next experiment was undertaken to test 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 (Definition 2) -- the more general an anaphor is with respect to its focused antecedent, the faster will it be read (see Figure 1 and Figure 2). This implies that a given NP anaphor co-referring with a more specific antecedent which 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, then the less informationally loaded the anaphor/antecedent pair is, the easier the anaphor is to process (see Figure 3).

The ILH does not make any prediction about the case in which the antecedent is not focused, although it is reasonable to assume that in this case reading time should increase with semantic distance, just because matching the anaphor with an antecedent different than the “default” discourse focus would be harder. Both this last intuitive hypothesis and Prediction 4 of the ILH can be easily tested by measuring the reading time of an anaphor following antecedents with a varying conceptual relation to the anaphor, and in different focusing states.

For example, consider the four examples below:

### Example 8

- 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 Example 8c and Example 8d focus the car and the boat respectively, but in Example 8a and Example 8b they focus the student. The ILH makes the following two specific predictions:

i) The anaphor The vehicle should be read faster in Example 8d than in Example 8c for the following reason. A boat (as in Example 8d) is a less typical member of the vehicles category than a car (as in Example 8c), 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 2). Therefore, the anaphor/antecedent pair in Example 8d (the vehicle, the boat) is less informationally loaded than the pair in Example 8c (the vehicle, the car). Because in Example 8d and Example 8c the antecedent is focused, the ILH entails that the anaphor in the less informationally loaded pair (in Example 8d) should be read faster (Prediction 4).

ii) The anaphor The vehicle should be read faster in Example 8c than in Example 8a, and faster in Example 8d than in Example 8b. 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 8c and Example 8d and therefore the anaphor in these two cases should be read faster than in the other two cases.

In addition, despite the inapplicability of the ILH to this case, it is expected that:

iii) The anaphor The vehicle will be read faster in Example 8a than in Example 8b because in both cases the antecedent is not focused and therefore a matching process is required. Because terms denoting typical category members are easier to match with the category term than terms denoting atypical members, the term the car (as in Example 8a), which denotes a more typical member of the vehicles category than the one denoted by the term the boat (as in Example 8b), 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 8a than in Example 8b.

The current experiment used materials similar to Example 8 to test these predictions.

## Method

**Materials:** Twenty-four experimental items similar in form to the one in Example 8 were constructed. First, a set of 24 category names was selected from the Battig & Montague (1969) typicality norms. For each category, the norms were used to select a pair of members, one typical and one atypical, so that the two members 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-pseudo-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 members, 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 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 8 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 was 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 that were recruited from the same population.

For the analysis, reading times more than 2 standard deviations away from the mean of each condition were deleted (affecting 4.76% of the data). The data from one participant was excluded from further analysis due to failure to meet the 80% correct answers criterion.

## Results

The mean reading times of the anaphors are listed in Table 7. An 2x2 ANOVA, Construction Type (it vs. wh) by Antecedent Typicality (typical vs. atypical), revealed no main effects for either typicality,  $F_1, F_2 < 1$ , or focus,  $F_1(1,26) = 1.79, p < .2$ ;  $F_2(1,23) = 1.78, p < .2$ . However, as expected, a significant interaction effect was obtained,  $F_1(1,26) = 8.92, p < .006$ ;  $F_2(1,23) = 8.33, p < .008$ .

The results were in most part consistent with the predictions of the ILH for this experiment which were individually tested in a set planned comparisons:

1) Prediction (i) was supported by the results. The category anaphor was read 25 ms faster on average when the antecedent was a focused atypical member than when it was a focused typical member, a reliable difference,  $F_1(1,26) = 5.4, p < .03$ ;  $F_2(1,23) = 4.56, p < .05$ . This shows that when referring to the focused antecedent, the ease of establishing reference increases with increasing C-difference.

2) One part of Prediction (ii) (the comparison between Example 8b and Example 8d) 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 focused, 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 8a and Example 8c) 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,  $F_1 < 1$ ,  $F_2 = 1.03$ .

3) 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 member than when it was an atypical one. However, this difference was only marginally significant,  $F_1(1,26) = 5.4$ ,  $p < .07$ ;  $F_2(1,23) = 4.56$ ,  $p < .07$ .

## 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, the easier it was to process. This result seems incompatible with some previous research which showed an opposite effect, namely that category anaphors are read faster when their antecedents are typical than when they are atypical (Garnham, 1989; Sanford, Garrod, & Boyle, 1977). However, in none of these 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 quite likely that upon the completion of a sentence participants verify their representation of the sentence.

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 a and c). When the category anaphor had a typical member 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 conceptual 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 which 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 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 members in the contexts used in the experiment on a scale of one to seven, one being highly atypical, and seven being highly typical. For twenty-two out of the twenty-four items that were used, the typicality ratings in context agreed on which category member was the more typical one with the Battig & Montague (1969) norms used to construct the materials. An ANOVA done on the ratings of the twenty-two 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,  $F_1(1,6) = 207.2$ ,  $p < .001$  ;  $F_2(1,21) = 89.5$ ,  $p < .001$ , with the typical items having a mean rating of 4.825 and the atypical items 1.851.

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 which 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 pragmatically motivated account of NP anaphor use. Derived from the Griceian maxim of quantity, the ILH associates the cost of processing an anaphor with a measure of informational load, a measure that is related to the semantic distance between the antecedent and the anaphor. According to the ILH, the usage 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 repetition 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 repetition penalty to the use of an anaphor which 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 non-repetitive 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 (Experiment 5). Thus, a category anaphor is less informationally loaded when its antecedent is an atypical member of the category than when it is a typical member (see Definitions 2 and 3).

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, Grosz, & Gilliom, 1993; Gordon & Scearce, 1995) were incorrect in generalizing results obtained with repetitive anaphors to claims pertaining to the entire class of NP anaphors. In particular, the work reported in a series of studies done by Gordon and collaborators was based on the assumption that the repetition 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 repetition penalty, as Gordon argues, 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 repetition penalty was not observed in cases where a pronoun should have been used. As shown by Experiments 1, 2, 3, and 4, the repetition 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 non-repetitive 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 like task oriented dialogues like the ones 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.

## **Extensions and Future Directions**

In its present formulation the ILH is not a complete theory of NP anaphor use, and leaves a number of important issues that require further specification. Of particular importance is the exact nature of informational load. It was argued here that informational load of an anaphor can be assessed by the degree of difference between the semantic representation of the antecedent and the anaphor. Obviously, this is not a sufficiently specific definition. A complete understanding of the processing and use of NP anaphors would require a precise specification of what informational

load is. However, the fact that the ILH is capable of making testable predictions without further specification of informational load, helps dissociate the ILH from any specific issues regarding theories of conceptual knowledge.

Quantifying the basic notions of the ILH, namely informational load and the amount of new information added by a given anaphor, may have some important practical implications because it would provide a way to computationally implement and formalize the entire ILH. A formal model of the ILH could be used as a criterion for selecting an appropriate antecedent in practical applications of artificial discourse parsers facing the task of associating a given anaphor with its appropriate antecedent. The ILH suggests that antecedent selection can be thought of as an optimization problem in which an anaphor is matched with the antecedent, which in combination with that anaphor, scores better than all other possible antecedents in that it achieves its functional goal (identifying the antecedent and possibly adding some new information) with the smallest informational load.

Empirically, formalizing the basic notions of the ILH would allow for a much wider range of empirical tests of the ILH's predictions. To test the predictions of the ILH in the most general form without committing to a particular method of quantifying its notions, the present research relied on focus manipulation as the only empirical technique. Although the findings reported here provide the most general support for the ILH (because they are independent of any specific issues of quantifying informational load and new information), there are other, more direct, predictions of the ILH that were not tested in this research. For example, when the antecedent is unfocused, the ILH predicts that for anaphors that do not add new information, there exists a specific threshold informational load value defined as that amount of informational load that is sufficient for identifying the antecedent. Anaphors with an informational load value (with respect to their unfocused antecedent) higher than this threshold value would be harder to process than anaphors with exactly that value of informational load because their excessive informational load would not

serve any function. Anaphors with an informational load lower than that threshold value with respect to that antecedent would also be harder to process because they would not successfully identify the antecedent. Quantifying the ILH's basic notions would allow for a calculation of that threshold value, a calculation that would enable empirical tests that do not rely on focus but instead maintain a constant focal status of the antecedent. In similar vein, once the notions of informational load and new information have been quantified, the effect of the interaction between them on anaphor processing can be tested directly independently of focus.

Another aspect of the ILH which was discussed earlier but not tested directly, is its applicability to pronouns. Given any antecedent, a pronoun should be the least informationally loaded non-elliptical 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. In contrast to Centering theory (Grosz, Joshi, & Weinstein, 1995), 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) 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.

Finally, the contrast between the high informational load repetitive anaphors which are read slower when their antecedent is focused, and low informational load non-repetitive 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, non-repetitive 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 which can be applied even when using a pronoun is impossible (as in the case of contrast terms like those in Experiment 4 above).

## 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 pragmatics as a basis for a theory of NP anaphor processing distinguishes the ILH from previous accounts of NP anaphor processing (e.g., Gordon, Grosz, & Gilliom, 1993, Grosz, Joshi, & Weinstein, 1995) which is based on the assumption that phenomena of the kind described in this research cannot be explained by pragmatic principles. The work reported here shows that phenomena of NP anaphor processing can be explained on the basis of pragmatic principles involving cost and function, and that conceptual representation must be a key factor in that explanation. NP anaphors, like any other linguistic device, serve a certain function and have a processing cost which is related to underlying cognitive mechanisms. The ILH is an explanation of NP anaphor processing that takes all these factors into consideration and shows how NP anaphor processing is the product of their interaction. It is the combination of linguistic function and cognitive principles that should constitute the basis for a psychological explanation of any aspect of language use.

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## FOOTNOTES

<sup>1</sup> Obviously, definite NP's demonstratives, and proper names can be used non-anaphorically, and pick up real-world referents directly. However, the present work addresses only the anaphoric use of these expressions.

<sup>2</sup> The ILH is intended to apply only to those expressions that can be used normally to refer to an entity, such as bird and robin when referring to a robin. It does not apply to highly general expressions which might still accomplish successful reference in many contexts, such as winged thing and organism, but which invite further inferences because they are not normally used to refer to those entities. The issue of inferences invited by various forms of reference is complex and is not dealt with in this paper (for a discussion of this issue see Cruse, 1977).

<sup>3</sup> I would have used the term “conceptual difference” instead of the arbitrary “C-difference” if it was not for the fact that C-difference, as defined in Definition 2, can be negative and thus is incompatible with most people’s intuitions about conceptual difference.

<sup>4</sup> The expression “the thing” is not usually used to refer to birds and is therefore not within the scope of the ILH (see Footnote 2). It is only used in Figure 1 to illustrate the effect of semantic distance on anaphors more general than their antecedents.

<sup>5</sup> Ease of processing is commonly thought of as a measure of discourse coherence. For example, van-Dijk & Kintsch (1983) view 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, Ch. 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.

<sup>6</sup> 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. This is discussed in more detail in the next section.

<sup>7</sup> 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, the present discussion of centering theory will continue to use of the terms “focus” and “reference to the discourse focus”.

Table 1

Examples of all 4 conditions in Experiment 1.

Construction	Antecedent Position	
	First	Second
	(i)	(ii)
It-cleft (focus on first noun)	It was <u>the robin</u> that ate the apple. \$	It was <u>the robin</u> that ate the apple. \$
	The bird \$ seemed very satisfied. \$	The fruit \$ was already half rotten. \$
	Did the bird touch the fruit?	Did the bird touch the fruit?
	(iii)	(iv)
Wh-pseudo-cleft (focus on the second noun)	What the robin ate was <u>the apple</u> . \$	What the robin ate was <u>the apple</u> . \$
	The bird \$ seemed very satisfied. \$	The fruit \$ was already half rotten. \$
	Did the bird touch the fruit?	Did the bird touch the fruit?

Note. The focused noun is underlined for expository purpose. In the text presented to participants, nothing was underlined. The \$'s mark fragment boundaries. Each fragment was presented separately on the screen. Each item ended with a yes/no question to make sure participants read the text, and to assess their understanding.

Table 2

Reading times of category anaphors with category-exemplar antecedents under different focus conditions in Experiment 1.

Construction	Antecedent Position	
	First	Second
It-cleft	<u>443</u>	481
Wh-pseudo cleft	468	<u>444</u>
Difference	25	-37

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 3

Reading times of category-exemplar anaphors with category antecedents under different focus conditions in Experiment 2.

Construction	Antecedent Position	
	First	Second
It-cleft	<u>453</u>	468
Wh-pseudo cleft	483	<u>430</u>
Difference	30	-38

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.

Construction	Antecedent Position	
	First	Second
it-cleft	<u>415</u>	409
wh-pseudo cleft	403	<u>443</u>
Difference	-12	33

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.