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Pragmatic versus Form-based Accounts of Referential Contrast: Evidence for Effects of Informativity Expectations

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Characterizing the relationship between form-based linguistic knowledge and representation of context has long been of importance in the study of on-line language processing. Recent experimental research has shown evidence of very rapid effects of referential context in resolving local indeterminacies on-line. However, there has been no consensus regarding the nature of these context effects. The current paper summarizes recent work covering a range of phenomena for which referential contrast has been shown to influence on-line processing, including prenominal and postnominal modification, focus operators, and intonational focus. The results of the body of work suggest that referential context effects are not limited to situations in which the linguistic form of the utterance directly specifies the point of contact with context. Rather, context effects of a pragmatic, Gricean nature appear to be possible, suggesting the relationship between linguistic form and context in rapid on-line processing can be of a very indirect nature.

KEY WORDS: referential contrast; pragmatic knowledge; discourse context; eyetracking; nominal modifier.

INTRODUCTION

While sentence processing research in the 1970s and 1980s was primarily concerned with problems of recovering syntactic structure on-line, recent work in the field has seen an increasing emphasis on the real-time *interpretation* of

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linguistic input. The bulk of the work in this latter domain stems from the pioneering work of researchers such as Crain and Steedman (1985) and Altmann and Steedman (1988), who focused attention on the role of representations of discourse models in the process of resolving on-line syntactic ambiguities. This work in turn has its roots in model-theoretic approaches to linguistic meaning, which attempt to formally characterize the relationship between structural aspects of language and a representation of its meaning in terms of information conveyed about properties and relations of entities instantiated in an abstract model of the world (for an extensive introduction, see Dowty *et al.*, 1981). Such theoretical accounts take seriously the notion that the function of linguistic meaning is to communicate information about the world (either the actual world, or possible things and events in the world). This "aboutness" function is coupled with the observation from linguistics that language is compositional in nature, i.e., that units of language can be combined by means of abstract rules that generalize over tokens, with units of the same type providing a uniform contribution to the well-formedness and meaning of the structure they are embedded in, regardless of specific content. The central contribution of work by Crain *et al.*, and colleagues was to explore the processing consequences of this coupling of linguistic structure and "aboutness." In doing so, they demonstrated the on-line effects of manipulations of the discourse context on sentence processing and the incremental nature of interpretive processes. A substantial body of work has built on these initial observations, with much debate revolving around the role of model-based information and its relationship to structural or lexical information and the relative time-course for the use of these sources of information (Altmann *et al.*, 1992; Altmann *et al.*, 1994; Binder *et al.*, 2001; Britt, 1994; Paterson *et al.*, 1999; Spivey-Knowlton & Tanenhaus, 1994).[2] These studies have typically focused on information that is linguistically instantiated in a discourse context preceding some target sentence and have measured the impact of this contextual information on the reading time of sentences that are syntactically ambiguous at some point in the sentence.

[2] Not all sentence processing work dealing with interpretation concerns model-based aspects of semantic interpretation. A notable exception is the recent volume by Frazier (1999), which focuses primarily on questions about processing at a representational level of Logical Form, argued to be a representational level taking as its input a purely syntactic representation and having as its output a representation that then feeds into the interpretive component. While some models of grammar assume such an intermediate level of representation (e.g., see Heim & Kratzer, 1997), not all do (Dowty *et al.*, 1981). However, regardless of whether they assume an intermediate level of Logical Form, both approaches assume a model-theoretic interpretive component. This paper will restrict itself to model-based aspects of semantic interpretation, leaving aside questions having to do with the directness of the relationship in the grammar between syntactic structure and model-based aspects of semantic interpretation.

The theoretical emphasis on model-based aspects of interpretation has provided the impetus for the development of methodological tools that can more directly measure interpretive processes. Reasoning that eye movements to a visual display are typically closely linked to the interpretation of referential linguistic expressions (as found by Cooper, 1974), Tanenhaus *et al.,* (1995) carried out a study involving contextual manipulations to a visual display that were analogous to Altmann and Steedman's linguistically instantiated contextual manipulations. Real-time eye movement patterns were found to differ dramatically across visual contexts, confirming both that interpretation occurs in a highly incremental fashion in time and that on-line language processing is highly sensitive to specific properties of the model against which the linguistic input is being interpreted. Subsequent studies have demonstrated that the mapping of referential expressions to a visual model is initiated on the basis of extremely partial information, beginning well before the offset of the referring word, and can be modulated by a variety of information sources such as lexical frequency (Dahan *et al.,* 2001), prosodic information (Dahan *et al.,* 2000; Sedivy *et al.,* 1995), verb-based semantic constraints (Chambers *et al.,* 2000), to name just a few. In fact, commitments about mapping linguistic expressions to entities in the visual model can even be made entirely prior to the onset of the referential expression itself, provided the verb-based information and visual context are sufficiently constraining (Altmann & Kamide, 2000).

In this paper, I will focus specifically on the kind of discourse model manipulations originally introduced by Steedman and colleagues. Specifically, these studies focused on contextual effects on processing temporarily ambiguous sentences with modified noun phrases, such as *The fireman broke down the door with the rusty lock*, in which the underlined portion of the sentence is typically (in the absence of context) interpreted as introducing an instrument argument (e.g., *with the axe*), rather than initiating a modifier phrase where the prepositional phrase *with the rusty lock* provides additional descriptive information about the door. Steedman and others have argued that modifier phrases typically signal a contrastive function, where the modifier is used to provide distinguishing information about the referent in a context where there are multiple entities denoted by the head noun. Demonstrations of contextual effects have involved instantiating more than one referent in the discourse context that corresponds to the head noun (e.g., two doors), thereby creating the conditions in the model that motivate the use of the modifier phrase. Such model-based manipulations are particularly interesting as they involve a rich representation of the model of interpretation that requires linking up a type of linguistic expression with entities other than the referent itself, taking into account the relationship between the referent entity and other entities in the model. In contrast, some of the

visual world studies simply require linking up a referential expression with a visually displayed entity that provides the best match with the linguistic input, which might potentially be accomplished through much less semantically enriched, lower-level mechanisms. It turns out that the notion of contrastiveness is implicated in the interpretation of a variety of different linguistic phenomena. The following section will introduce these phenomena, discuss some of the empirical studies carried out to date to investigate the on-line use of model-based information pertaining to referential contrast, and evaluate the likely source of these effects.

EMPIRICAL STUDIES OF LINGUISTIC PHENOMENA INVOLVING REFERENTIAL CONTRAST

Postnominal Modifiers

Crain and Steedman (1985) characterized the discourse requirements of definite modified NPs as presuppositional. Presupposition refers to a varied set of linguistic expressions which signal that certain information is assumed to be taken for granted and backgrounded in a discourse model. Frequently, presuppositions are associated with particular lexical items. For instance, "factive" verbs such as *know* are said to presuppose the truth of their complements, whereas otherwise similar verbs like *believe* do not (as an example, consider the difference in the speaker's commitment to the truth of the complement clause in the sentence *Most Americans know that the US won the War of 1812* versus *Most Americans believe that the US won the War of 1812*.) Presuppositions involving modifier phrases can be characterized as constructional rather than lexical cases of presupposition, with some particular abstract structure carrying the presupposition rather than a lexically specified item. Steedman and Altmann (1989) point out that other candidates for this notion of presupposition include focus-related constructions such as clefting, as in the sentence *It was Harry who ate the beans*, which presupposes that someone ate the beans or, minimally, that the question of who ate the beans is under discussion. According to Crain and Steedman, the use of a definite modified NP requires the satisfaction of the following presuppositions: (1) that the entire NP refer to a single, uniquely identifiable individual in the discourse model; (2) that the existence of an individual matching the description of the NP be taken as implicitly assumed in the discourse; and (3) that some (nonunitary) set of individuals identified by the head noun be represented in the discourse model. This view resembles claims regarding the presuppositions associated with definite NPs more generally. It has been claimed (e.g., Heim, 1982) that definite NPs presuppose both the existence and the uniqueness of a referent that is denoted by the descriptive content of the NP. However, Crain and Steedman's presupposi-

tional account of modified definite NPs has been called into question (e.g., Clifton & Ferreira, 1989). In particular, a hallmark of presuppositions is that they are typically not cancellable; though they can be accommodated into a context in which the presupposition has not previously been entered into the discourse, the discourse sounds anomalous if accommodation of the presuppositional material is inconsistent with the previous discourse. However, as Clifton and Ferreira have pointed out, it seems unproblematic to explicitly cancel the contrastive function of a modifier phrase. It fact, it appears to be the case that in general, the majority of modifiers are used in contexts where the modification is *not* used for contrastive purpose (see, for example, Fox & Thompson, 1990). I will return to the question of the relationship between contrastive function and modification in the discussion of adjectival modifiers to be found below.

Sentences Containing Focus Operators

A related line of research has been concerned with sentences involving what have been called *focus operators* in the semantics literature. Focus operators include words such as *only* or *even,* which typically occur in the presence of intonational focus marking (e.g., *Only JOHN smokes cigars*), where the meaning of the sentence requires that some constituent be interpreted as marked for focus. The actual interpretation of the sentence depends on an interaction between focus marking and the specific semantic contribution of the focus operator (e.g., see Krifka, 1991, and Rooth, 1985, 1992 for detailed discussion of the semantics of focus). The semantic effect of focus in the sentence above is to ensure that beyond simply asserting that John smokes cigars, the sentence also establishes a distinction between John and an implicit, contrasting set of individuals and asserts that none of these individuals smokes cigars. The precise relationship between the focused element (John) and the implicit contrast set is determined by the specific focus operator; notice how a slightly different sentence with a different focus operator such as *Even John smokes cigars* now conveys that John is somehow less likely to smoke cigars than an implicit, contrasting set of entities.

A clever series of experiments by Ni *et al.* (1996) experimentally combined ambiguities hinging on the interpretation of modifier phrases (which were assumed to carry a contrastive function) together with focus operators, which *require* the establishment of a contrast set. Ni *et al.* constructed experimental stimuli that manipulated the presence of a focus operator with ambiguity of modifier phrases, resulting in the comparison of sentences such as:

(1) a. *Only businessmen loaned money at low interest* were told to record their expenses.
    b. *The businessmen loaned money at low interest* were told to record their expenses.

The italicized portions of these sentences are ambiguous with respect to whether the string is to be understood as a simple past tense clause or whether it involves a reduced relative clause modifying *businessmen.* The unitalicized portion disambiguates toward the latter interpretation. The logic of the experiments designed by Ni *et al.* was to introduce an operator which requires precisely the type of contrast that modified nouns are said to be associated with. Thus, the presence of the focus-sensitive operator should heighten the expectation for a modified noun, thereby reducing or eliminating any difficulty with the normally dispreferred structure. Ni *et al.* argued that the default expectation is that the contrast required by *only* is established via the potential modifier attached to the noun, rather than the head noun itself, leading to the expectation that *businessmen* will form part of the background information used to compute the contrast set. In other words, the preferred contrast is not between businessmen and some other group of entities, but between businessmen who were loaned money and businessmen with some other distinct property.

The results of the study showed that the presence of a focus operator dramatically reduced the difficulty normally associated with temporarily ambiguous reduced relative clauses. In addition, when the focus operator was present in a sentence that included a prenominal modifier (i.e., an adjective), as in the sentence *Only wealthy businessmen loaned money at low interest were told to record their expenses,* difficulty with the reduced relative ambiguity re-emerged, suggesting that when the prenominal modifier offered an opportunity for setting up a contrast set, the processing system made this commitment incrementally, prior to encountering the ambiguous phrase. Hence, upon encountering the ambiguous phrase, there was no longer any pressure to establish a contrast set.

More recent work by Sedivy (2002) has further examined the effects of focus on syntactic ambiguity resolution and carried out direct contextual manipulations involving the availability of an explicit contrast set in the discourse. Temporarily ambiguous target sentences such as (3) and (4) were paired with contexts such as those depicted below:

Context sentence:

(2) a. *All of the secretaries and accountants were made to take a tough computing course.*
b. *All of the secretaries in the company were made to take a tough computing course.*

Target sentence:

(3) *Only the secretaries prepared for the exam and earned significant pay raises.*

(4) *Only the secretaries prepared for the exam passed and earned pay raises.*

The presence of the contrast set (i.e., *accountants*) in the context sentence had a clear impact on the processing of these ambiguous sentences; when the sentence was disambiguated toward a main clause, as in (3), the contexts with a contrast set, such as (2a), resulted in faster reading times relative to contexts with no such contrast set (as in (2b)). The opposite was true for sentences disambiguated toward the reduced relative clause, such as (4), where the presence of the contrast set indicated greater difficulty with the disambiguating region of the sentence. This experiment demonstrated that the focus effect was directly sensitive to representations of the model. An additional study in the series also verified that the presence of the focus operator was essential in order for the model manipulations to have an effect; similar manipulations of contrast involving sentences that were not marked for focus did not show any contextually based effects.[3]

These studies involving the interaction of linguistically marked focus and model-based manipulations highlight the processing consequences of a linguistic phenomenon where a representation of the information in the model is essential in order to arrive at a complete interpretation of the sentence. Thus, in order to ascertain precisely what assertion is being made when a speaker utters a sentence with a focus operator such as *Only John smokes cigars,* the membership of the contrast set must be identified on the basis of explicit (and possibly also implicit) contextual information. Hence, interpretation is heavily dependent on contextually supplied information about the model, and there is a close relationship between linguistic structure and the nature of the information that needs to be retrieved from the context. It is perhaps not too surprising, then, that rapid context effects are seen to emerge under these conditions.

Intonational Focus

While focus operators typically require some constituent in the sentence to be marked for focus, and specify a relationship between the focused and contrasting entities, contrastive focus can appear in a sentence in the absence

[3] In fact, when the context sentence did not make available an explicit contrast set, and the target sentence contained a focus operator, a subsequent experiment indicated that subjects showed evidence of misanalyzing the target sentence when it was continued as a main clause, in comparison to an unambiguous control sentence. This suggests that the context manipulations, together with the focus marking, have the potential to not only eliminate but in some cases reverse the usual processing bias in favor of a main clause reading (but see Paterson *et al.,* 1999, and Clifton *et al.,* 2000).

of an explicit focus operator. Typically, contrastive focus is marked intonationally by a L+H* accent (Pierrehumbert & Hirschberg, 1990) and is characterized by a steep pitch slope (Bartels & Kingston, 1994). In such a case, while a contrast set may be evoked, the relationship between the focused and contrasting entities is not explicit and may be determined by context. For instance, uttering the sentence *JOHN smokes cigars* may convey a correction of someone's mistaken assertion that someone else smokes cigars, call attention to John's smoking habits relative to other entities, or express a contrast in knowledge pertaining to other individuals versus John (e.g., as in *I don't know whether anyone else likes cigars, but JOHN smokes cigars*). In all cases, however, there is a requirement that some contrast set be instantiated.

Eberhard *et al.* (1995) reported an eye monitoring study that manipulated visual contexts and the presence of intonational focus. Instructions with intonational focus such as *Touch the LARGE red square* were compared to instructions of identical lexical content but with no intonational focus on the size adjective. Visual displays accompanying the instructions contained two objects that could be described by the size adjective (e.g., for the example provided above, two large objects). For half of the displays, the target object occurred together with an object that contrasted only on the size dimension (e.g., a small red square) while no such object contrasting with the competitor object (e.g., the other large object) was present. Given that eye movement studies with spoken language typically show evidence of participants beginning to make referential commitments on a highly incremental basis, it was reasoned that the presence of contrastive focus in these displays would lead to an early identification of the target object. This is because referential identification of the competitor object does not satisfy the constraints imposed by focus marking for the presence of a contrasting entity, allowing for the referent to be identified upon hearing the focused adjective, even though the predicate itself was semantically consistent with more than one entity. As with the manipulations involving focus operators above, the presence of intonational focus depended on the appropriate information in the model; when both the target and the competitor objects had a contrasting object present in the display, this advantage for the target object disappeared.[4]

There are clear parallels among all three of the cases described so far. In all cases, some distinct linguistic trigger (i.e., modification, focus operators, or intonational focus) carries with it constraints on the model against

[4] These results should be interpreted with caution, as the effects of context on interpreting intonational focus have not been systematically pursued. In fact, a somewhat different manipulation of contrastive focus reported in Sedivy *et al.* (1999) did not show effects of intonational focus. It is possible that such effects interact with contrastiveness associated with modification in ways that are not yet clearly understood.

which the utterance is interpreted. The experiments summarized here all show evidence of rapid, incremental consultation of the pertinent information in the model.

Adjectival Modifiers

In this section, I will evaluate the implications of Crain and Steedman's (1985) claims regarding modification in the context of recent work on the incremental interpretation of prenominal adjectives. While the classical ambiguity resolution experiments addressing referential context effects involved postnominal modification (because this is the locus of the syntactic ambiguity), the general claims about contrastive presuppositions extend to all cases of restrictive modification occurring with definite noun phrases, including prenominal adjectives. In fact, some indirect evidence for the contrastiveness of adjectives is provided in the Ni *et al.* (1996) study involving focus operators and adjectives; recall that, in the presence of a focus operator, when an adjective preceded the head noun, there was no tendency to interpret the ambiguous phrase as a modifier. This was presumably because, like postnominal modifiers, adjectives provide a readily accessible means by which to establish a contrast set.

More direct evidence of the contrastive function of adjectives can be found in the eye movement experiments reported by Sedivy *et al.* (1999). In these experiments, participants heard instructions such as *Pick up the tall glass,* in which the noun was modified by a scalar adjective. It was found that the target was distinguished from a competitor object (another object that could be described by the same adjective, such as a pitcher in the current example) more quickly when a contrasting object of the same category was present in the display (e.g., a shorter glass) than when no such contrasting object was present. These data suggest that when faced with a choice between a contrastive and noncontrastive interpretation of an adjective, participants systematically preferred the contrastive interpretation. Strikingly, this preference emerged within hundreds of milliseconds of the onset of the adjective, indicating extremely rapid use of the model-based information in mapping the referential phrase to its referent.

Recall that in our earlier discussion of postnominal modification, the view of modification as involving constructional presupposition was called into question on the basis of the easy cancellability of the contrastive function. Although the results of the study above appear to support a view of modification as broadly contrastive, there are reasons to doubt this account. First, there was no evidence of any difficulty whatsoever with noncontrastive uses of the adjective; in these cases, participants showed no evidence of searching the display for a contrasting object and never commented on

the use of an adjective in the absence of contrast. Second, the contrastive function was as apparent with indefinite noun phrases as definite noun phrases. Most seriously, however, further recent investigations with adjectives reveal that the effect of referential contrast does not extend to all adjective types. In particular, similar experiments involving color adjectives fail to show a preference for a contrastive interpretation, with no detectable advantage coming from the presence of a contrasting object to the target (Sedivy, in press). In other words, in a visual display containing, say, two blue objects, and accompanied by an instruction such as *Pick up the blue cup*, where the display also contains a contrasting red cup, there is no bias in favor of the target object over the other blue object, and the presence of the contrasting red cup does not speed identification of the target as compared to displays in which it is not present. This casts doubt on the generalizability of the contrastive function of adjectives and, in turn, the notion of this function as an example of constructional presupposition, which should be indifferent to the lexical content of the modifier.

In light of these results, the finding of referential contrast effects for scalar adjectives such as *tall* might be reinterpreted to take into account some underlying semantic differences between scalar and color adjectives. In general, adjectives, like other predicates such as nouns or verbs, are taken to denote properties or sets of entities. Hence, the meaning of an adjective such as *red* is simply the link between that word and the set of red things in the model. However, it is notoriously difficult to extend such an account to adjectives like *tall*, whose meaning is extremely fluid and context-dependent. Thus, unlike for most other predicates, it is impossible to identify some specific property that satisfies the use of the predicate, independently of an implicit or explicit comparison class. The range of values for what can count as tall depends in part on the noun that it modifies *(a tall girl* versus *a tall building)* as well as on contextually based expectations (*a tall ladder* can mean different things depending on the intended function of the ladder). Indeed, formal linguistic analyses of scalar adjectives typically build in some notion of a free variable corresponding to a comparison class that must get contextually fixed (e.g., see Bierwisch, 1987; Kennedy, 2001). This distinction provides a somewhat different perspective from which to view the referential contrast effect observed with scalar adjectives. A linguistic trigger may still be responsible for the effect, but rather than residing in generalizations about modifier constructions, it may have its origin in the lexical specification of scalar adjectives, which requires the identification of a comparison class in order to be semantically evaluated as contributing to a true or false assertion. In the following section, I will discuss additional experimental results that suggest an entirely less direct relationship between linguistic expressions and information in the model for the purposes of incremental interpretation.

A LINGUISTICALLY MEDIATED VERSUS PRAGMATIC INFERENTIAL ACCOUNT OF REFERENTIAL CONTRAST

The seminal work by Steedman and colleagues was revolutionary for the field of sentence processing for bringing the problem of interpretation into the domain of inquiry. However, with respect to its account of the relationship between linguistic form and context of interpretation, this work was relatively conservative in that it assumed that the role of contextual information was largely determined by knowledge of linguistic form. All of the mechanisms underlying the experimental results discussed thus far make similar assumptions. For instance, according to Crain and Steedman's account of modifier presuppositions, it is knowledge of the semantic characterization of modifiers that specifies the relevant contextual information. Similarly, with focus constructions, it is knowledge of the semantic requirements of focus that drives the processing system to find some expedient way to establish contrast sets. Contrastive effects obtained with scalar adjectives can be similarly interpreted: It is knowledge of the semantics of the adjective that triggers a search for a pertinent comparison class. In fact, the growing body of evidence for rapid contextual effects in processing dovetails nicely with an increasing recognition in the semantics and pragmatics literatures that a full account of the meaning of linguistic expressions frequently requires some form of systematic interface of linguistic form with nonlinguistic contextual information. Hence, it is not unreasonable to hypothesize that to the extent that rapid contextual effects can be observed in on-line language processing, they are triggered by systematic relationships between linguistic form and the model of interpretation that can be formally characterized as part of the linguistic representation of the linguistic units themselves. All of the data presented above are compatible with such a constrained hypothesis.

An alternative account of the relationship between linguistic form and contextual information is one in which the context effects can be driven by *nonlinguistic* knowledge. For instance, Ferreira and Clifton (1989) provide an explanation for the typical contrastive function of modifiers in this vein; they propose that it derives from general communicative expectations such as those outlined by Grice (1975), in which hearers may reasonably assume that speakers will plan their utterances to be optimally informative. However, Ferreira and Clifton view it as unlikely that such inferential mechanisms are implicated in on-line language processing due to their computational intractability. For the remainder of this section, I will summarize experimental results suggesting that such mechanisms may indeed be involved in the incremental processing of language.

Sedivy (in press) reported experimental data involving adjectival modifiers denoting material (e.g., *plastic, metal*) as well as scalar and color adjec-

tives. The finding of referential contrast effects with material adjectives, similar to scalar adjectives, suggested that semantic differences across adjective types in fact are unlikely to be responsible for the observed contextual effects. This argument was made on the grounds that unlike scalar adjectives, material adjectives do not require the identification of a comparison class in order for their semantic value to be ascertained; in other words, it is possible to determine the contribution of the adjective to the truth or falsity of a sentence solely on the basis of a fragment such as *this is a plastic* . . . irrespective of the noun it modifies or idiosyncratic contextual expectations. What seemed to distinguish those adjectives which exhibited a contrast effect (i.e., scalar and material adjectives) from the class of adjectives that did not, rather, was the frequency with which that particular type of adjective was spontaneously generated to describe an object in a context where no modification was required to distinguish it from other objects in the visual context. Specifically, it was found that participants very frequently produced phrases such as *the blue cup* even when only a single cup was present, and hence simply referring to the object as *the cup* would have been sufficient. In contrast, material and scalar adjectives were hardly ever produced except when required for purposes of unambiguous referential identification (e.g., with a visual display containing two objects of the same category). The linking of on-line effects of referential contrast with the rarity of encountering an adjective as part of the typical means of describing the object suggests that the processing mechanism may indeed be driven by general communicative expectations; it is precisely in those situations where the speaker produces more information than is usual (by producing either a scalar or material adjective) that the hearer attributes some particular discourse-based motive for its use and understands the adjective as being present for the purpose of providing referential disambiguation.

An interesting prediction follows from this view: If referential contrast effects originate in expectations regarding usual or default descriptions rather than in the semantics of the adjectives themselves, it should be possible to empirically dissociate adjectival type from expectations of informativity. Thus, if there are circumstances under which the default description of an object would *not* include a color adjective, then we would expect the use of a color adjective in these circumstances to trigger an inference of contrastive function. It is of interest to note that the color property was always an orthogonal property rather than a stable property for the objects involved in the studies above; that is, the objects were likely to be of any color at all rather than some particular typical color. If speakers generally attempt to minimize redundancy in language production, they might tend to encode color less frequently when it is a highly predictable property of the object (as would be the case with, say, bananas, which are fairly predictably

yellow, though they may also appear in other colors). Such referents are a promising test case for evaluating the predictions of a pragmatic inferential account.

An elicited production study was conducted to determine whether speakers are less likely to encode color when this property is predictable from the object's category. This set of objects included organic objects such as bananas (typically yellow), peas (typically green), as well as artifacts that generally occur in some particular color (such as erasers, typically pink, or duct tape, generally silver). Speakers provided instructions to a conversational partner to move an object to a new location on a horizontal workspace between them. In order to target a specific object for description for each trial, the speaker saw a pair of schematic diagrams of the display board, with numbers representing each of the objects in the display. The first diagram indicated the arrangements of objects in the display at the start of the trial, and the second diagram indicated the desired arrangement as a result of moving one of the objects on the board to some new location. Participants were told that their goal was to communicate to their partner the identity of the target object to be moved and its desired new location. They were told to communicate this information in any way they chose and were not provided with any further guidance as to the content of their utterances. This task was the same as the elicited production task used in earlier studies with scalar, material, and color adjectives.

Figure 1 shows the percentage of trials for which speakers provided a color adjective in situations where it was *not* necessary for referential dis-

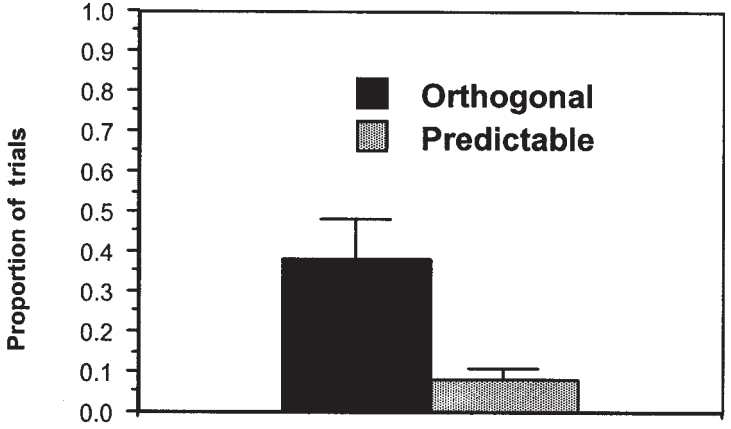

Fig. 1. Proportion of trials in elicited production task containing a color adjective in displays where mention of color was not necessary for unique reference.

ambiguation, comparing the predictable color items with earlier data from objects where color was an orthogonal property. It can be seen that for the objects where color is predictable, the color property is rarely included in the description of the object; when color was an orthogonal property, however, it was frequently included in the description, even when not required for referential disambiguation.

A comprehension study was conducted to determine whether the use of a color adjective would trigger a contrastive interpretation in these situations where color is not expected to be a part of the typical description of the object. As in earlier studies investigating the on-line processing of color adjectives in the visual world paradigm, subjects were given instructions such as *Pick up the yellow banana* in the context of a visual display of objects. Each trial contained a competitor object, which bore the property denoted by the adjective (e.g., a yellow notebook). Contextual manipulations involved the presence or absence of a contrasting object of the same category as the target (e.g., a brown banana).

Figure 2 shows eye movements over time (beginning at the onset of the adjective) for each of the objects in displays that did not contain a contrasting object. Eye movements were distributed between the target and competitor object until most of the noun had been heard. Fixations to the target began to significantly diverge from fixations to the competitor object

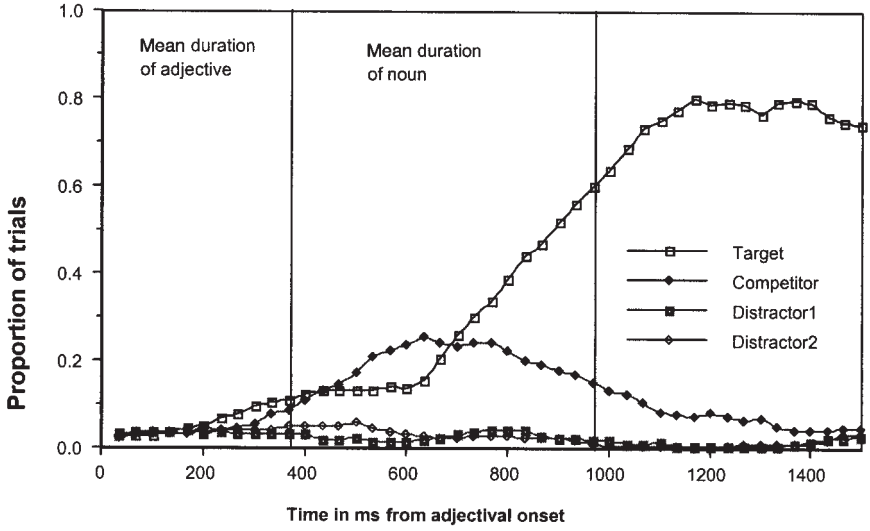

Fig. 2. Eye movements over time beginning at the onset of the adjective for each of the objects in the visual display for trials in which the display did *not* contain a contrasting object.

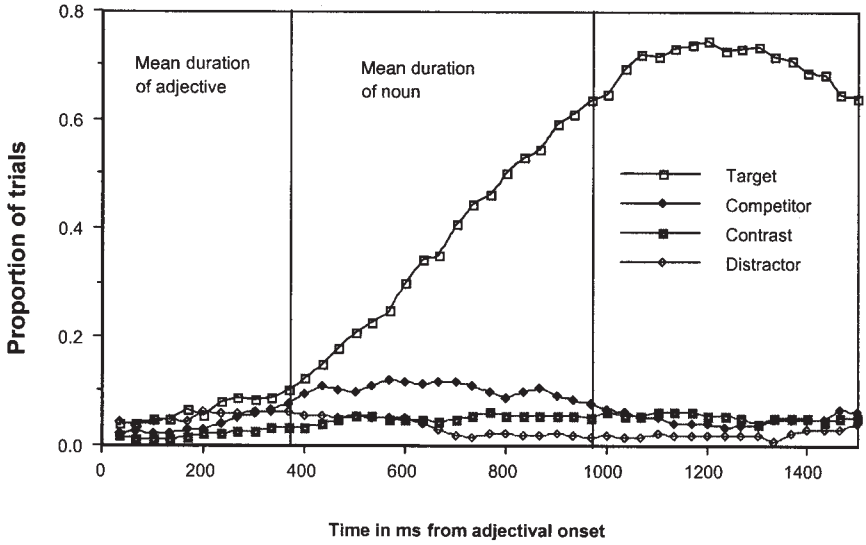

Fig. 3. Eye movements over time beginning at the onset of the adjective for each of the objects in the visual displays for trials containing a contrasting object.

at 400 ms after the onset of the head noun and remained significantly different for the remainder of the trial.[5]

Figure 3 shows eye movements for each of the objects for displays with a contrasting object of the same category as the target. It can be seen that the target object tended to be fixated earlier, and the competitor object less, than was the case in the noncontrastive condition. Fixations for the target begin to significantly diverge from fixations to the competitor object 133 ms after the onset of the noun (reflecting eye movements planned prior to the onset of the noun). This translates into a 267 ms advantage for referential identification of the target simply as a result of the contextual manipulation.

The presence of a contrastive bias for color adjectives under circumstances where the color adjective does not seem to be part of the default description of the object provides strong support for the view that contrastive

[5] It is interesting to note that for a brief time following the presentation of the color adjective, the competitor object was fixated *more* frequently than the target. This difference was significant at 233 ms after the adjective offset (presumably reflecting eye movements planned at or shortly after the adjective offset). This difference was marginally significant at the time frames immediately before and after this point. This observation is interesting given that the color of competitor objects was always orthogonal rather than predictable.

interpretations associated with prenominal adjectives are driven by the informational status of the adjective, and not its lexical type (or construction type). Thus, it suggests that the role of contextual information in on-line processing is not limited to situations where the linguistic representation itself signals the contribution of context for its interpretation. Rather, more pragmatically based mechanisms that are sensitive to general communicative principles may be responsible for effects of referential contrast.

An interesting prediction follows from this conclusion. If contrast effects with adjectives reside not in information about the constructional or lexical type, but in the fact that the amount of information that is provided in the instruction exceeds the expected amount of information, then such effects should generalize to cases where information content is higher than expected even if no adjective occurs. This can be achieved by examining highly specific subordinate-level nouns such as *collie* in situations where the less informative basic-level noun *dog* would typically be used. Preliminary data from a study currently under way suggest similar effects of referential contrast in these cases. Participants viewed computer-generated displays containing ClipArt images of four objects and heard instructions containing a subordinate-level expression such as "*Click on the collie.*" Each trial contained an object that served as a cohort competitor and began with the same syllable as the target (e.g., collar); half of the trials contained a contrasting object of the same basic-level category as the target (e.g., a dalmatian), in addition to a distractor object, while the remaining half simply contained two unrelated distractor objects.

Figure 4 shows eye movements to objects in the displays without a contrast beginning from the onset of the target noun. A substantial competitor effect is visible, with fixations to the competitor outranking fixations to the target early in the presentation of the noun. This presumably reflects the fact that the competitor nouns were typically higher in frequency than the low-frequency subordinate-level target nouns. Fixations begin to reliably converge on the target object at 633 ms after the onset of the target noun, which coincides with the mean target offset.

Figure 5 shows eye movements to the objects in displays with a contrasting object of the same basic-level category. Fixations to the target begin to reliably converge on the target object relative to the competitor at 533 ms after noun onset, reflecting a 100 ms advantage for the displays with contrast, primarily through the reduction of the magnitude of the competitor effect.

This experiment provides suggestive confirmation of the relationship between informational status and context effects. However, the data should be interpreted with caution, as the temporal advantage is relatively subtle and is carried by a reduction in the competitor effect alone rather than as a joint facilitation in the location of the target and the reduction of the com-

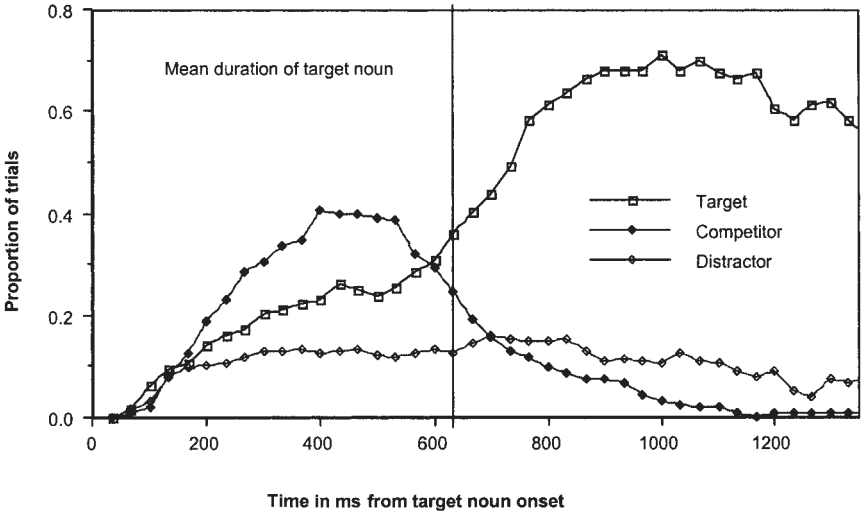

Fig. 4. Shows time course of eye movements initiated after the onset of the target noun for each of the objects in the visual display for trials in which the display did *not* contain a contrasting object.

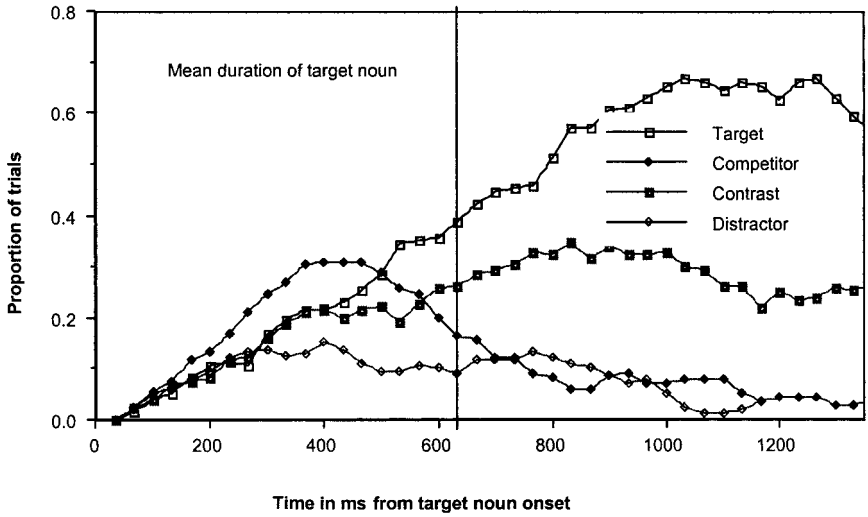

Fig. 5. Shows time course of eye movements initiated after the onset of the target noun for each of the objects in the visual display for trials in which the display contained a contrasting object.

petitor effect, as is more typically the case. It is possible that the presence of the semantically related contrasting object actually provided some additional competition for the target, eliminating any potential facilitation to the target due to context (e.g., see Yee & Sedivy, submitted, for evidence from eye movements for increased activation of semantically related lexical items). Further research is currently underway to tease apart effects of referential context from semantic relatedness.

CONCLUSIONS AND FURTHER QUESTIONS

The data presented in this paper underscore the sensitivity of on-line language processing to contextual information but also add to a growing body of data that suggest there is a less direct relationship between linguistic form and model-based effects than has generally been invoked for referential context effects. Rather than conform to the view sketched our earlier in the paper where model-based effects are driven primarily by knowledge of linguistic structures or lexical classes that specify some particular interface with context, the emerging data suggest a prominent role for pragmatic communicative principles in guiding commitments made on the fly in the course of linguistic interpretation. Perhaps an analogous development can be seen in literature dealing with early language learning. While much research in language development has concluded that control of pragmatic knowledge emerges slowly and is incomplete until very late in childhood, a number of recent proposals have focused on the potentially important role played by early understanding of intentionality and expectations about communicative behavior in learning new words. For instance, Clark (1990) makes an interesting claim regarding the source of the early bias children exhibit in favor of a one-to-one mapping of words to referent types, leading them to resist the use of a second term (e.g., *poodle*) to refer to an entity for which they already have a label (e.g., *dog*). Clark suggests that this bias (called the mutual exclusivity bias) has its roots in pragmatic constraints similar to those generating conversational implicatures—namely, that if the child and a speaker share a mutually known label for a referent, then the use of a new, unknown label is taken to refer to something distinct on the grounds that the speaker would have, in the normal case, simply used the default expression otherwise. This claim attributes a great degree of pragmatic sophistication to toddlers in the early word-learning stages. Along these lines, Bloom (2000) summarizes recent evidence for the role of perceived intentionality in a variety of early linguistic behaviors.

Indeed, strikingly similar questions regarding the relationship of referential contrast and form-based knowledge can be found in the developmen-

tal literature dealing specifically with the domain of adjectival modification. For instance, Gelman and Markman (1985) and Prasada and Cummins (2001) report a contrastive bias by young children in novel word learning situations where a nonsense word must be mapped onto some entity in a visually presented context. Thus, when presented with stimuli such as *Show me the fep one,* or *the large fep,* children show a tendency to interpret the novel word in a way that interprets the adjective as signaling a contrast between two objects of the same category. These authors have attributed the results to an underlying knowledge of contrastive function that is general to the adjectival category. However, more detailed investigations may turn out to show that such expectations are driven by similar pragmatic considerations as those argued to be responsible for the on-line processing effects summarized herein. Current work in our laboratory, for instance, suggests that young children show similar patterns of adjective production for color and scalar adjectives and that contrastive interpretations of adjectives in novel word learning situations are modulated by adjective type (as reported by Nadig *et al.,* 2001).

Though work in this vein is still in its infancy in both developmental and processing domains, it raises the intriguing possibility of a very central, and perhaps innately specified, role for human understanding of intentionally and its relationship to language. It also serves to signal the growing theoretical importance of developing cognitively plausible and computational tractable models of representing and implementing pragmatically based knowledge.

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