

Comprehending Conceptual Anaphors

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English pronouns must agree with their antecedents in number. But in some situations, pronouns violate this constraint, as in "I think I'll order a *frozen margarita*. I just love *them*." Three situations are identified in which such violations occur: (1) Plural (and technically illegal) pronouns are used to refer to frequently or multiply occurring items or events (as opposed to a unique item/event); (2) plural pronouns are used to refer to generic types (as opposed to a specific token); and (3) plural pronouns are used to refer to animate members of a collective set (as opposed to an individual member of a set). When sentences contained illegal, plural pronouns that referred to multiple items/events, generic types or collective sets, they were rated more natural (Experiment 1) and comprehended more rapidly (Experiment 2) than when the same sentences contained legal, singular pronouns. But when the sentences contained legal, singular pronouns and referred to unique items/events, specific tokens or individual members of a set, they were rated more natural and comprehended more rapidly. The results underscore the role that pragmatic information - perhaps in the form of mental models - plays in the on-line interpretation of conceptual anaphors, such as pro-nouns.

INTRODUCTION

Language is used to refer to things. Once something has been referred to, it can be re-referred to via certain linguistic devices. These devices are called anaphors, and the things they refer to are called antecedents.

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How does a comprehender know exactly which antecedent a particular anaphor refers to? This question interests psycholinguists as well as artificial intelligence (AI) specialists, particularly those working on natural language processing systems.

In many natural language processing systems, anaphors are resolved by certain heuristics, presumably the same heuristics employed by human comprehenders. Four constraints that guide this heuristic process are: (1) lexical constraints, cued by lexical markings such as number, gender and case; (2) syntactic constraints, e.g. Langacker's (1969) precede-command rule; (3) thematic constraints, cued by discourse markings such as topic, focus or foregrounding; and (4) pragmatic constraints, provided by the comprehender's knowledge and inferential reasoning about the real world (this list was adapted from Tyler & Marslen-Wilson, 1982).

Heuristics that capitalise on lexical constraints -number, gender and case -are most easily incorporated into natural language processing systems. They are also the heuristics that human comprehenders acquire earliest (Palermo & Molfese, 1972) and that novice writers are most successful at applying (Bartlett, 1984).

This paper investigates a particular case of pronominal anaphora, a case likely to cause difficulty for human comprehenders. At the least, these pronouns create problems for most all extant AI models of natural language processing (Webber, 1984). The reason is that these pronouns clearly violate one of the most elementary lexical constraints. Consider the following utterance (after Sidner, 1984):

- 1a. I want a new *Harley 1200*.
- b. *They're* really huge, but *they're* gas-efficient.

Although the pronoun in (1b) is plural, only singular nounphrases occur in (1a). Therefore, the pronoun clearly violates the lexical constraint. Yet, such violations occur frequently. Consider the following utterance, over-heard in a bar:

- 2a. I think I'll order a *frozen margarita*.
- b. I just love *them*.

Or the following comments, overheard on a university campus:

- 3a. My room-mate was so excited. She actually made *an A*.
- b. She doesn't make *them* very often.

Or the following exchange between an acquaintance (A) and myself (G):

- 4a. A: I can't believe you drive a *Fiat*.
- b. G: Why is that?
- c. A: *They're* so temperamental.

Or what I said a few days after the exchange in (4a-c):

5a. I need to call *the garage* [where my car was being serviced].

b. *They* said *they'd* have it ready by five o'clock, but I bet *they* won't.

In each of these examples, a plural pronoun occurs in the last sentence. But only singular nounphrases occur in the preceding sentences. In this sense, these pronouns are illegal.¹

In this paper, I suggest that these violations occur because pronouns do not refer literally to their preceding nounphrases; rather, pronouns are conceptual anaphors. For instance, the speaker in (2) was not proclaiming her affection for one specific frozen margarita; rather, she was proclaiming affection for many margaritas -perhaps all the frozen margaritas in the universe (or at least most of the ones she had ever tasted). Similarly, my acquaintance in (4) was not diagnosing the personality of the specific token of Fiats that I own; rather, he was diagnosing the personality of a generic type of automobile. And when I said that I needed to call the garage, I was not literally referring to a physical structure or place of business; rather, I was referring to the mechanics who work there. In other words, each of the speakers in (1) through (5) was referring to something more than what was represented by the literal preceding nounphrase; these speakers were, therefore, using *conceptual anaphors*.

The use of technically illegal but conceptually plausible plural pronouns demonstrates that pronouns are, as Hankamer and Sag (1976) claim, *deep anaphors*. Deep anaphors, such as pronouns, are pragmatically controlled, and they differ from surface anaphors, which require "parallelism in syntactic form" (Sag & Hankamer, 1984, p. 325). Pronouns belong to the set of expressions that Webber (1988, p. 61) calls *discourse anaphors*, because their meaning is established by the "evolving model of the discourse that the listener is constructing", rather than having their meaning explicitly specified in the discourse.

Both the conception of *deep anaphors* and *discourse anaphors* is captured in what I refer to as conceptual anaphors. Although all pronouns are *conceptual anaphors*, illegal plural pronouns are excellent demonstrations of conceptual anaphors because they cannot literally replace their preceding nounphrases (Tanenhaus & Carlson, 1990; Tanenhaus, Carlson & Seidenberg, 1985).

Illegal plural pronouns occur in at least three communicative situations. In one situation, plural pronouns are used to refer to things someone is likely to have multiples of, or events someone is likely to

¹I am using the term "illegal" in accordance with grade school textbooks', English language grammars' (Quirk & Greenbaum, 1978) and even professional publication manuals' (APA, 1983) prescription that "a pronoun must agree with its antecedent in person, number, and case".

experience repeatedly, for example:

6a. I need a *plate*.

b. Where do you keep *them*?

7a. Would you get me a *paper towel*?

b. *They're* in the kitchen.

8a. Yesterday was my *birthday*.

b. I used to really dread *them*, but yesterday I didn't care.

In (6), (7) and (8), the preceding nounphrases are sole items or events - *a plate, a paper towel, a birthday*. But because most households possess more than one plate (and most people keep those multiple plates together), because paper towels are usually dispensed in a roll of many, and because almost everyone has more than one birthday, the intended referent is a multiple item or event. To refer to multiple items or events, technically illegal, plural pronouns are used.

In a second communicative situation, illegal plural pronouns are used to refer to generic types. For example:

9a. My mother's always bugging to me wear *a dress*.

b. She thinks I look good in *them*, but I don't.

10a. Carla's downstairs watching *a soap opera*.

b. If she had her way, she'd watch *them* all afternoon.

11a. I enjoy having *a pet*.

b. *They* are such good companions.

In this communicative situation, the intended referents are the concepts in general. For instance, soap operas in general, not the specific one that Carla is currently watching, are what that the speaker in (10) believes Carla could watch all afternoon.

In a third communicative situation, illegal plural pronouns are used to refer to the animate members of a collective set, for instance, the members of *a team, a group or a musical band*. For example:

12a. The substitute teacher begged *the class* to stop misbehaving.

b. But *they* didn't pay any attention to her.

Members of less traditional collective sets are also referred to by plural pronouns. For example:

13a. After college, my sister went to work for *IBM*.

b. *They* made her a very good offer.

14a. You wouldn't believe how bad it is to work for *the city*.

b. *They* can never tell you whether your job will be covered in the next month's budget.

15a. I need to call *Sears*.

b. *They* made a mistake on my last credit card bill.

So, illegal plural pronouns are used in at least three communicative situations: They are used to refer to (a) frequent or multiple items or events, (b) generic types and (c) collective ets. Although the boundaries between these three situations might be sharper, what is common among sentence pairs (6) through (15) is that the pronoun in the second sentence refers to a plural concept.²

Illegal plural pronouns can be contrasted with singular (and technically legal) pronouns. A singular pronoun is used when the item or event being referred to is unique: The owner most likely has only one of such an item, or the event is most likely experienced only once. For instance, although most households have at least a few plates, they typically have only one iron. In the same way, many households have only one mop, and everyone experiences only one fortieth birthday. Therefore, a household's iron or mop, or an individual's fortieth birthday, is a unique item or event. Compare (6c, d), (7c, d) and (8c, d) with (6a, b), (7a, b) and (8a, b), respectively.

6c. I need *an iron*?

d. Where do you keep *it*?

7c. Would you get me *a mop*?

d. *It's* in the kitchen.

8c. Yesterday was my *fortieth birthday*.

d. I used to really dread *it*, but yesterday I didn't care.

A second situation in which a singular pronoun is used is when the antecedent is so distinct that it represents a specific token of a class of items. For instance, it might not be soap operas in general that Carla could watch all afternoon, but a specific soap opera that stars Michael Lewis. To refer to a specific token, speakers and writers typically use a legal, singular pronoun. For example, compare (9c, d), (10c, d) and (11c, d) with (9a, b), (10a, b) and (11a, b), respectively.

²One distinction between multiple items/events and generic types is that generic types are typically introduced as indefinite nounphrases, e.g. *a Fiat, a dress, a pet*. But multiple items/events can be definite, for instance, *my birthday* in (8), or *his towel*, which is a multiple item/event in (41a, b), as opposed to *his robe*, which is a unique item/event in (41c, d):

41a. Every morning after my husband showers he drops his towel on the floor.

b. And every couple of days, I found myself picking *them* up.

c. Every morning after my husband showers he drops his robe on the floor.

d. And every couple of days, I found myself picking *it* up.

- 9c. My mother's always bugging me to wear *a dress that she bought me last year for Christmas*.
d. She thinks I look good in *it* but I don't.
- 10c. Carla is downstairs watching *a soap opera that stars Michael Lewis*.
d. If she had her way, she'd watch *it* all afternoon.
- 11c. I enjoy having *a pet canary named "Chatty"*.
d. *She* is such a good companion.

A third situation in which a singular pronoun is used is to refer to an individual member, as opposed to a collective set. For example:

- 12c. The substitute teacher begged *the student* to stop misbehaving.
d. But *he* didn't pay any attention to her.
- 13c. After college, my sister went to work for *the vice president of IBM*.
d. *He* made her a very good offer.
- 14c. You wouldn't believe how bad it is to work for *the mayor*.
d. *He* can never tell you whether your job will be covered in the next month's budget.

So, a singular pronoun is used to refer to (1) a unique item/event, (2) a specific token and (3) an individual member, whereas plural pronouns are used to refer to (1) multiple items/events, (2) generic types and (3) collective sets.

RESEARCH QUESTIONS

This research answered three questions: First, how natural are illegal, plural pronouns? Do they disturb educated, native speakers? Perhaps they do because they violate a primary, lexical constraint: They do not match their literal antecedents in number. But perhaps such illegal, plural pronouns are acceptable because pronouns refer conceptually. If so, then illegal, plural pronouns should be more acceptable when their antecedents are multiple items/events, generic types or collective sets, than when their antecedents are unique items/events, specific tokens or individual members.

Secondly, how easily comprehended are illegal, plural pronouns? Do they cause momentary comprehension problems? They should if human comprehenders resolve pronominal anaphors by applying the simplest heuristic first: Search for an antecedent that matches in person, case and number. This is the first thing that virtually all artificial intelligence models do, and the first thing that virtually all psychological models propose that humans do. In contrast, a few psychological models propose that heuristics are applied in parallel (Tyler & Marslen-Wilson, 1982). If heuristics are applied in parallel, then these plural pronouns should not disrupt comprehension because - even though they violate lexical constraints - they satisfy pragmatic constraints.

Thirdly, are pronouns really interpreted conceptually? For instance, is the speaker of (6a) really asking where the listener keeps more than one plate? Are dresses, in general, what the mother of (9a) is always bugging her to wear? Is it actually a group of people who manage the city who cannot tell you whether your job will be budgeted in the upcoming month?

TABLE 1
Example Sentence Pairs

Multiple items/events vs unique items/events	
I need a plate. Where do you keep them?	Multiple item Plural pronoun
I need a plate. Where do you keep it?	Multiple item Singular pronoun
I need an iron. Where do you keep them?	Unique item Plural pronoun
I need an iron. Where do you keep it?	Unique item Singular pronoun
Generic types vs specific tokens	
My mother's always bugging me to wear a dress. She thinks I look good in them but I don't.	Generic type Plural pronoun
My mother's always bugging me to wear a dress. She thinks I look good in it but I don't.	Generic type Singular pronoun
My mother's always bugging me to wear a dress that she bought me last year for Christmas. She thinks I look good in them but I don't.	Specific token Plural pronoun
My mother's always bugging me to wear a dress that she bought me last year for Christmas. She thinks I look good in it but I don't.	Specific token Singular pronoun
Collective sets vs individual members	
The substitute teacher begged the class to stop misbehaving. But they didn't pay any attention to her.	Collective set Plural pronoun
The substitute teacher begged the class to stop misbehaving. But it didn't pay any attention to her.	Collective set Singular pronoun
The substitute teacher begged the student to stop misbehaving. But they didn't pay any attention to her.	Individual member Plural pronoun
The substitute teacher begged the student to stop misbehaving. But he didn't pay any attention to her.	Individual member Singular pronoun

These three research questions were answered using an experimental approach. The same target sentence was presented in four conditions, as illustrated in Table 1. In one condition, the target sentence contained a plural pronoun, and its preceding sentence contained a multiple item/event, a generic type or a collective set. In a second condition, the preceding sentence also contained a multiple item/event, a generic type or a collective set, but the target sentence contained a singular pronoun. In a third condition, the target sentence contained a plural pronoun, and its preceding sentence contained a unique item/event, a specific token or an individual member. And in a fourth condition, the target sentence contained a singular pronoun, and its preceding sentence contained a unique item/event, a specific token or an individual member.

In total, 48 sets were constructed, each set comprising four pairs of sentences constructed by factorially combining (1) whether the target sentence of each pair contained a plural pronoun, as opposed to a singular pronoun, and (2) whether the preceding sentence contained a multiple item/event, a generic type or a collective set, as opposed to a unique item/event, a specific token or an individual member. Sixteen sets were constructed to manipulate multiple items/events vs unique items/events, 16 sets were

constructed to manipulate generic types *vs* specific tokens, and 16 sets were constructed to manipulate collective sets *vs* individual members.

The first experiment answered the first research question: How natural are illegal plural pronouns? Educated, native English speakers rated each target sentence's naturalness in relation to its preceding sentence.

EXPERIMENT 1

Method

A total of 65 native English speakers participated in the experiment. These subjects were faculty, graduate students, and upper-division undergraduates. To minimise the subjects' exposure to similar sentences, each subject rated only two members of each set: one with a multiple item/event, a generic type or a collective set, and the other with a unique item/event, a specific token or an individual member.

The subjects' task was to read each sentence pair and to rate "how natural" the second sentence seemed in reference to the first". The meaning of natural, the subjects were told, was "how likely it is that you might hear such a sentence or produce such a sentence". The subjects used a 5-point scale, with 5 denoting "very natural" and 1 "not very natural".

Results

If illegal, plural pronouns are acceptable, but only when they refer to multiple items/events, generic types or collective sets, then sentences containing plural pronouns should be rated as more natural when preceded by multiple items/events, generic types or collective sets than when preceded by a unique item/event, a specific token or an individual member. In the same way, a singular pronoun should be more acceptable when preceded by a unique item/event, a specific token or an individual member, rather than multiple items/events, generic types or collective sets.

In other words, the type of preceding nounphrase (i.e. whether it represents a multiple item/event, a generic type or a collective set *vs* a unique item/event, a specific token or an individual member) and the number of the pronoun in the target sentence (plural *vs* singular) should interact. That is what was found.

Multiple Items/ Events vs Unique Items/ Events. The mean rating for target sentences preceded by multiple items/events *vs* unique items/events is shown in Fig. 1. As predicted, analyses of variance (ANOVAs) revealed a significant interaction between preceding nounphrase (multiple *vs* unique item/event) and pronoun number (plural *vs* singular) - $\min F'(1,23) = 44.51$. When preceded by multiple items/events, target sentences were rated more natural when they contained plural as opposed to singular pronouns [$\min F'(1,20) = 24.33$]. In contrast, when preceded by unique items/events, target sentences were rated less natural when they contained plural pronouns [$\min F'(1,36) = 48.50$]. In addition, when the sentences contained plural pronouns, they were rated more natural when they were preceded by multiple items/events as opposed to unique items/events [$\min F'(1,32) = 60.16$]. In contrast, when they contained singular pronouns, they were rated more natural when they were preceded by unique items/ events [$\min F'(1,20) = 15.23$].

The main effect of pronoun number (plural *vs* singular) was not reliable ($\min F' < 1.0$); however, the main effect of preceding nounphrase (multiple *vs* unique item/event) was marginally reliable: When the sentences were preceded by multiple items/events, they were rated slightly more natural ($M = 3.45$) than when they were preceded by unique items/events ($M = 3.23$) - $\min F'(1,24) = 3.97$, $P < 0.07$.

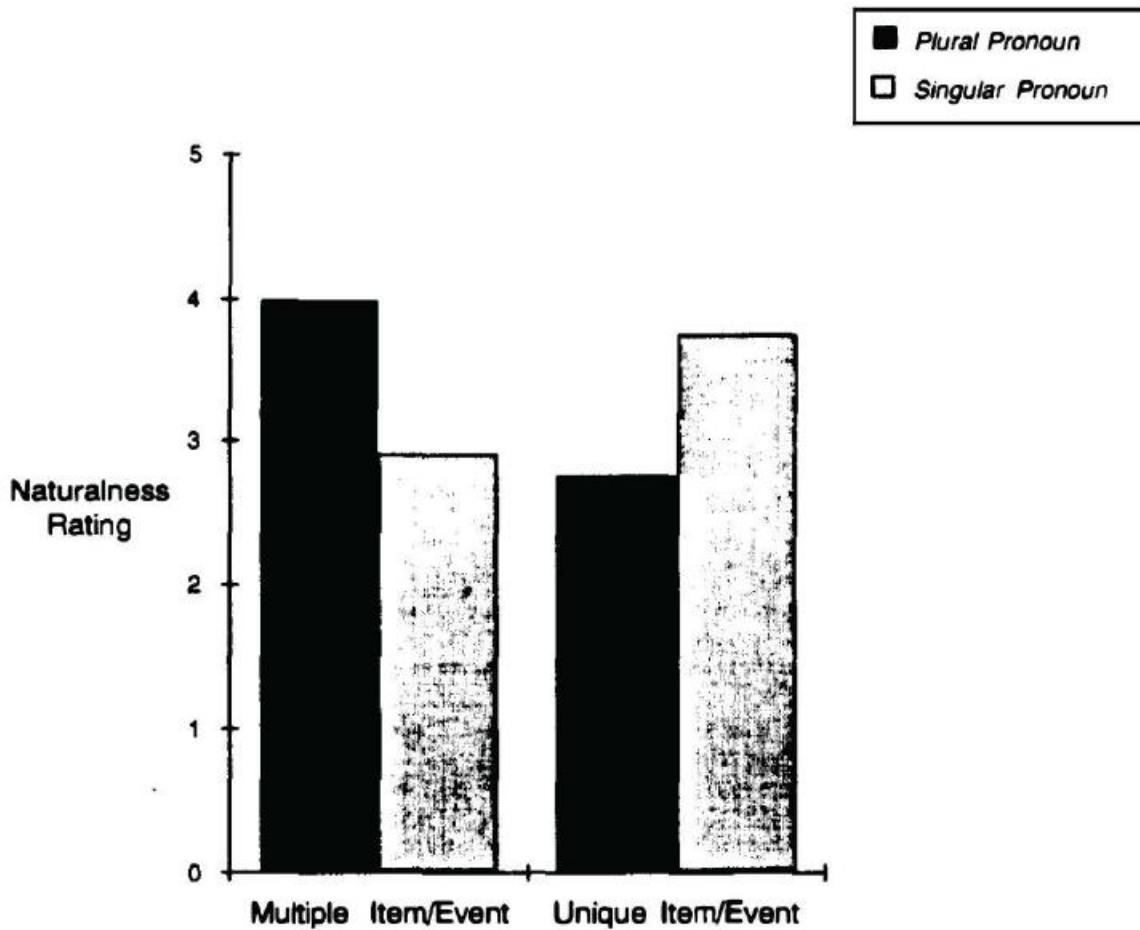


FIG. 1. Mean naturalness rating for target sentences preceded by multiple vs unique items/ events.

Generic Types vs Specific Tokens. The mean rating for target sentences preceded by generic types vs specific tokens is shown in Fig. 2. As predicted, preceding nounphrase (generic type vs specific token) reliably interacted with pronoun number (plural vs singular) - $\min F'(1,20) = 16.80$. When the target sentences were preceded by generic types, they were rated more natural when they contained plural as opposed to singular pronouns [$\min F'(1,20) = 9.318$]. In contrast, when the sentences were preceded by specific tokens, they were rated less natural when they contained plural pronouns [$\min F'(1,24) = 13.87$]. In addition, when the sentences contained plural pronouns, they were rated more natural when they were preceded by generic types rather than specific tokens [$\min F'(1,19) = 13.07$]. In contrast, when the sentences contained singular pronouns, they were rated more natural when they were preceded by specific tokens [$\min F'(1,19) = 5.410$]. Neither the main effect of preceding nounphrase (generic type vs specific token) nor the main effect of pronoun number (plural vs singular) was significant (both P 's > 0.40).

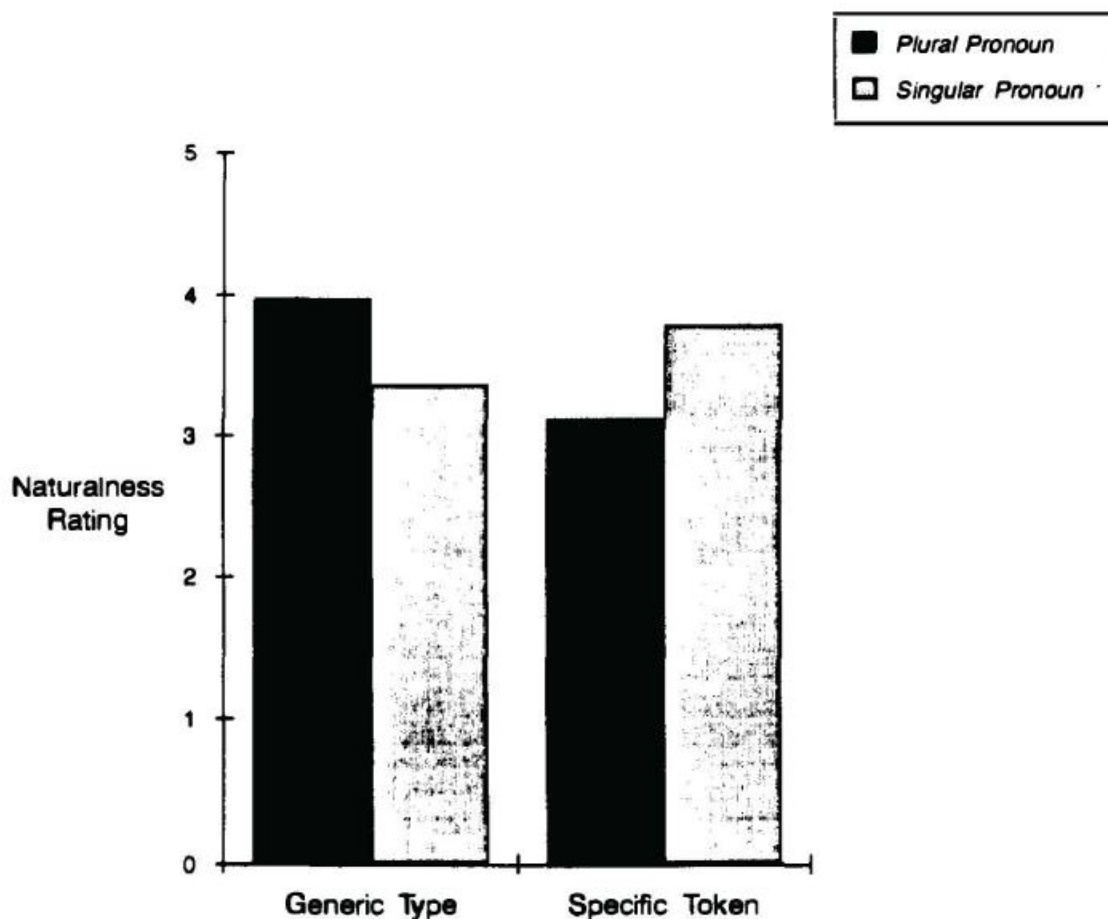


FIG. 2. Mean naturalness rating for target sentences preceded by generic types vs specific tokens.

Collective Sets vs Individual Members. The mean rating for target sentences preceded by collective sets vs individual members is shown in Fig. 3. Again, as predicted, preceding nounphrase (collective set vs individual member) reliably interacted with pronoun number (plural vs singular) - $\min F'(1,24) = 52.77$. When the target sentences were preceded by collective sets, they were rated more natural when they contained plural as opposed to singular pronouns [$\min F'(1,22) = 37.46$]. In contrast, when the sentences were preceded by individual members, they were rated less natural when they contained plural as opposed to singular pronouns [$\min F'(1,26) = 21.63$]. In addition, when the target sentences contained plural pronouns, they were rated more natural when they were preceded by collective sets as opposed to individual members [$\min F'(1,24) = 28.55$]. In contrast, when the sentences contained singular pronouns, they were rated more natural when they were preceded by individual members [$\min F'(1,21) = 27.20$]. Again, neither the main effect of preceding nounphrase (collective set vs individual member) nor the main effect of pronoun number (plural vs singular) was significant (both P 's > 0.40).

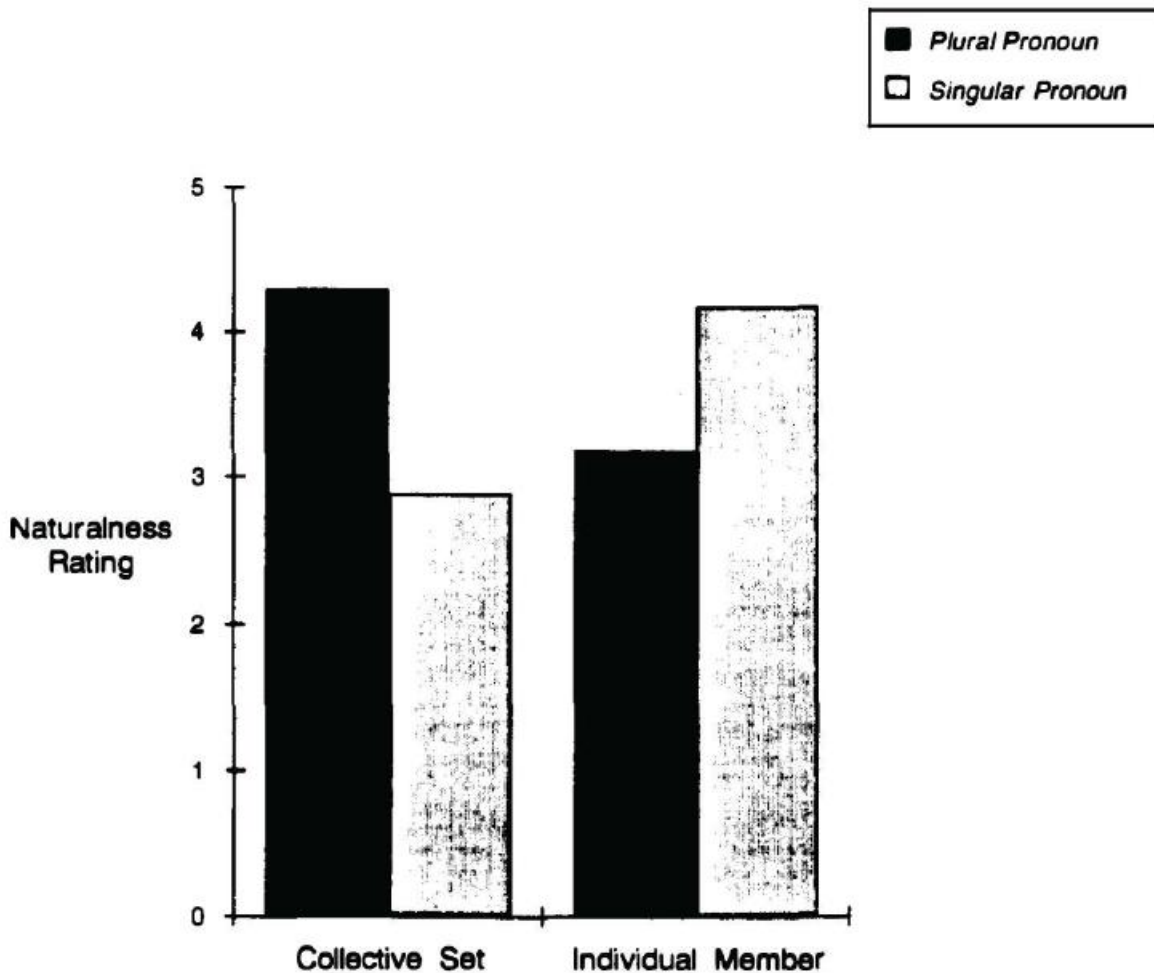


FIG. 3. Mean naturalness rating for target sentences preceded by collective sets vs individual members.

Discussion

Experiment 1 demonstrated that educated, native English speakers often find the use of illegal, plural pronouns very natural. In fact, in some communicative situations, illegal plural pronouns are more acceptable than legal singular ones. These are situations when the pronouns refer to multiple items/events, generic types or collective sets. These data demonstrate that pronouns are not literal replacements for preceding nounphrases; instead, they are conceptual anaphors.

How easy are illegal plural pronouns to comprehend? One prediction is that they are difficult to comprehend because they violate lexical constraints. If human comprehenders apply lexical heuristics first - as all AI models do - then comprehenders will experience immediate comprehension difficulties. In the worst case, the reference might never be resolved; in a more optimistic case, comprehension might be delayed until higher-level heuristics are applied. In either case, comprehension will be impaired.

However, another prediction arises from a view of pronoun resolution proposed by Tyler and Marslen-Wilson (1982). They suggest that the heuristics are applied in parallel. So while one set of constraints is being tested and perhaps violated, other constraints can be tested and possibly satisfied.

Therefore, violating only the lexical constraints should not abort the resolution process or require waiting for higher-level heuristics. Instead, pragmatic constraints are tested immediately. Because illegal plural pronouns meet pragmatic constraints, they should not cause comprehension difficulties. Indeed, they should be no more difficult to comprehend than legal singular pronouns.

The second experiment tested this prediction with a laboratory task frequently used to measure how easily pronouns are comprehended. As the subjects read the target sentences, their reading speed was recorded. Presumably, the more easily the pronouns are comprehended, the faster the subjects' reading speed (Clark & Sengul, 1979; Garrod & Sanford, 1977; 1983; Garnham, 1981; 1984; Haviland & Clark, 1974; Sanford & Garrod, 1981; Yekovitch & Walker, 1978; Yekovitch, Walker & Blackman, 1979).

The second experiment also answered another question: Are pronouns really interpreted conceptually? After reading each sentence pair, the subjects paraphrased it. These paraphrases were analysed to answer this third research question.

EXPERIMENT 2

Method

A total of 72 subjects read the sentence pairs on individual video-display monitors. Each trial was preceded by the word *Ready*, which disappeared when the subjects pressed the response key. Then, the first sentence of each pair appeared towards the top of the screen, and it remained for a period of time proportionate to its number of characters. After this first sentence disappeared, the target sentence appeared towards the bottom of the screen. It remained until the subjects pressed their response key to indicate they were finished reading the sentence. After the target sentence disappeared, the word *Paraphrase* appeared. At this point, the subjects "retold [aloud] the sentence in their own words", and their paraphrases were recorded on audio-tape. When the subjects finished each paraphrase, they pressed their response key, and the next trial began.

Results: Reading Speed Data

If illegal, plural pronouns are easy to comprehend because they satisfy pragmatic constraints, although they violate lexical constraints, then sentences containing plural pronouns should be read more rapidly when preceded by multiple items/events, generic types or collective sets than when preceded by unique items/events, specific tokens or individual members. Similarly, illegal plural pronouns should be more difficult to comprehend when they violate pragmatic constraints; that is, sentences containing plural pronouns should be read less rapidly when preceded by unique items/events, specific tokens or individual members than when preceded by multiple items/events, generic types or collective sets.

In other words, the type of preceding nounphrase in the first sentence (i.e. whether it represents a multiple item/event, a generic type or a collective set as opposed to a unique item/event, a specific token or an individual member) should interact with the number of the pronoun in the second sentence. That is what was found.

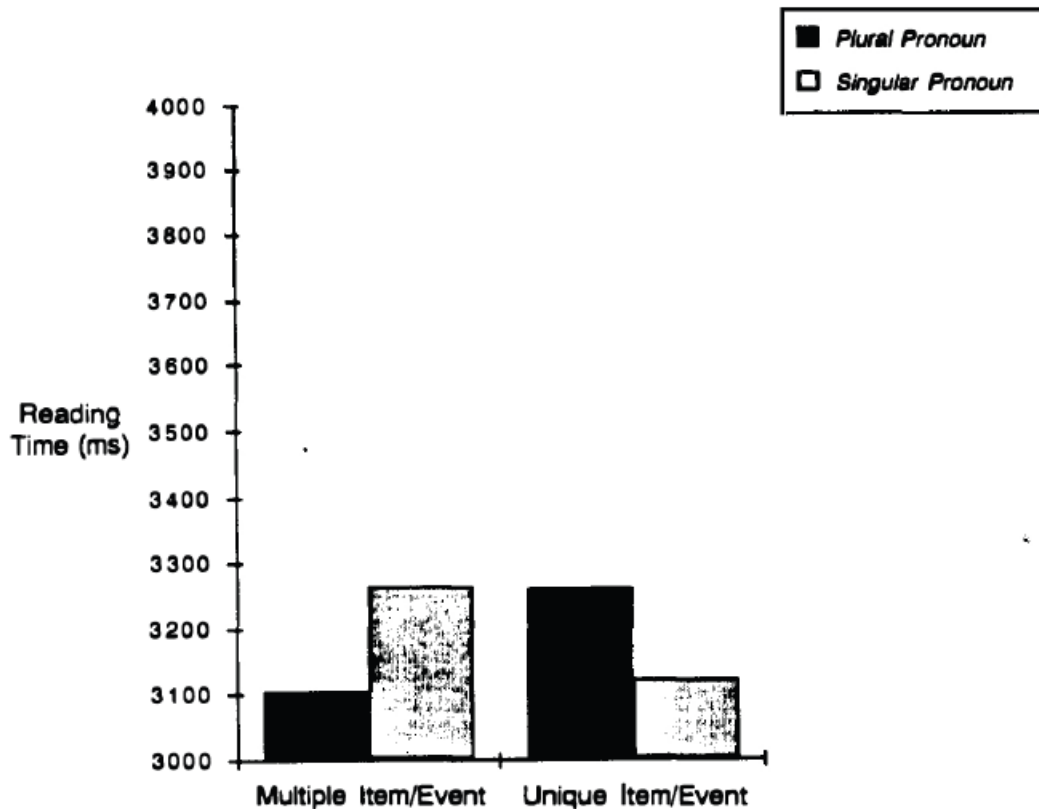


FIG. 4. Mean reading times to target sentences preceded by multiple vs unique items/events.

Multiple vs Unique Items/Events. The mean reading speed for target sentences that were preceded by multiple vs unique items/events is shown in Fig. 4. As predicted, preceding nounphrase (multiple vs unique item/event) reliably interacted with pronoun number (plural vs singular) – min $F'(1.59) = 7.203$. When the target sentences were preceded by multiple items/events, they were read more rapidly when they contained plural as opposed to singular pronouns [$F1(1,68) = 6.903$; $F2(1,15) = 6.578$]. In contrast, when the target sentences were preceded by unique items/events, they were read less rapidly when they contained plural as opposed to singular pronouns [$F1(1,68) = 4.559$; $F2(1,15) = 7.689$]. In addition, when the sentences contained plural pronouns, they were read more rapidly when they were preceded by multiple items/events [$F1(1,68) = 5.114$; $F2(1,15) = 7.272$]. In contrast, when the sentences contained singular pronouns, they were read more rapidly when they were preceded by unique items/events [$F1(1,68) = 6.098$; $F2(1,15) = 4.106$]. Neither the main effect of preceding nounphrase (multiple vs unique item/event) nor the main effect of pronoun number (plural vs singular) was significant (both min F 's < 1.0).

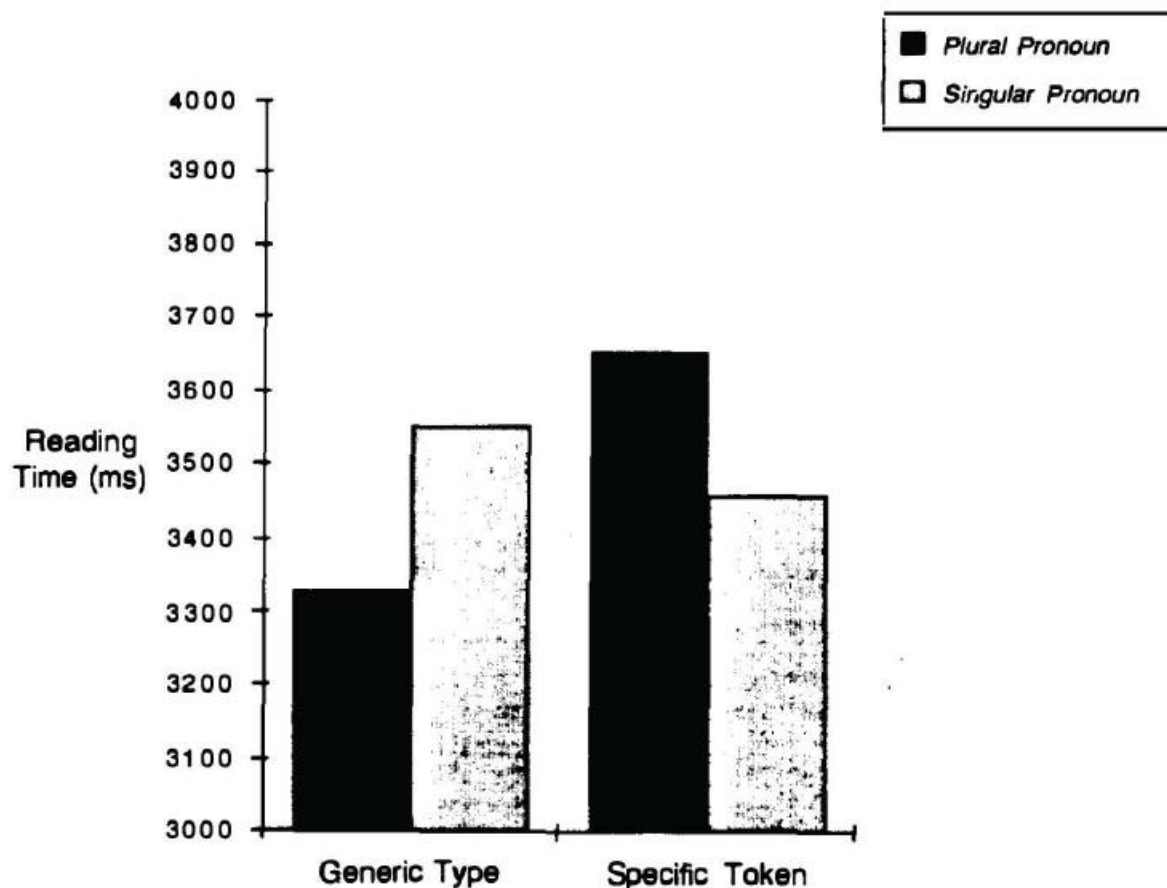


FIG. 5. Mean reading times to target sentences preceded by generic types vs specific tokens.

Generic Types vs Specific Tokens. The mean reading speed for sentences that were preceded by generic types vs specific tokens is presented in Fig. 5. Again, as predicted, preceding nounphrase (generic type vs specific token) reliably interacted with pronoun number (plural vs singular) - min $F'(1,24) = 5.232$. When the target sentences were preceded by generic types, they were read more rapidly when they contained plural as opposed to singular pronouns [min $F'(1,29) = 4.177$]. In contrast, when the target sentences were preceded by specific tokens, they were read less rapidly when they contained plural as opposed to singular pronouns [$F(1,68) = 8.776$; $F(1,15) = 5.864$]. In addition, when the sentences contained plural pronouns, they were read significantly more rapidly when they were preceded by generic types [min $F'(1,22) = 5.298$]. In contrast, when the sentences contained singular pronouns, they were read more rapidly when they were preceded by specific tokens, although this difference was not very reliable [$F(1,68) = 2.870$, $P < 0.09$; $F(1,15) = 2.703$, $P < 0.118$]. Again, neither the main effect of preceding noun phrase (generic type vs specific token) nor the main effect of pronoun number (plural vs singular) was significant (all P 's > 0.15).

Collective Sets vs Individual Members. The mean reading speed for target sentences preceded by collective sets vs individual members is shown in Fig. 6. As predicted, preceding nounphrase (collective vs individual) significantly interacted with pronoun number (plural vs singular) - min $F'(1,33) = 8.76$. When the sentences were preceded by collective sets, they were read more rapidly when they contained plural as opposed to singular pronouns [min $F'(1,28) = 4.008$]. In contrast, when the sentences were preceded by individual members, they were read more slowly when they contained plural as opposed to

singular pronouns [$\min F'(1,33) = 4.277$]. In addition, when the sentences contained plural pronouns, they were read more rapidly when they were preceded by collective sets [$\min F'(1,29) = 4.961$]. In contrast, when the sentences contained singular pronouns, they were read more rapidly when they were preceded by individual members [$F1(1,68) = 10.38$; $F2(1,15) = 5.99$]. Again, neither the main effect of preceding nounphrase (collective vs individual) nor the main effect of pronoun number (plural vs singular) was significant (both $\min F's < 1.0$).

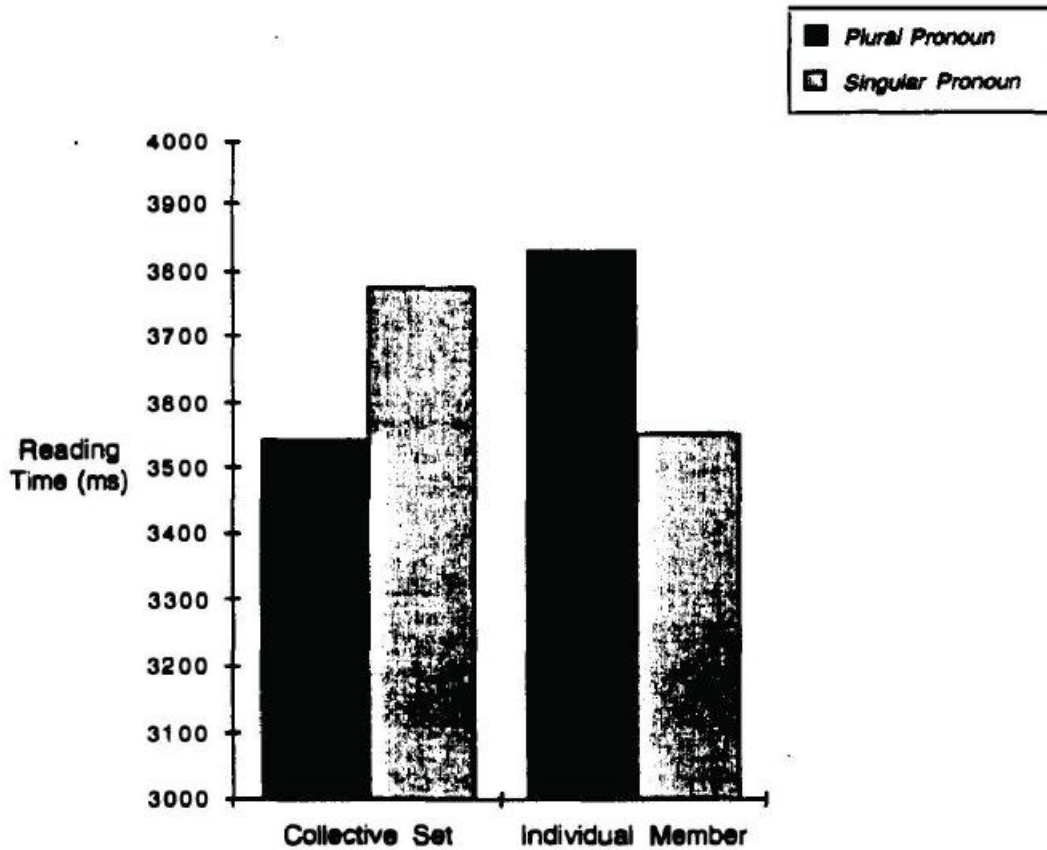


FIG. 6. Mean reading times to target sentences preceded by collective sets vs individual members.

Results: Paraphrase Data

If pronouns are interpreted conceptually, then plural pronouns preceded by multiple items/events, generic types or collective sets should be interpreted as referring to plural concepts. In contrast, a singular pronoun preceded by a unique item/event, a specific token or an individual member should be interpreted as referring to a singular concept.

To test this hypothesis, the subjects' paraphrases were transcribed and analysed. Verbatim repetitions were excluded, even if the subjects combined the two sentences into one sentence or merely left out a word or two. Rather, the subjects had to "restate" each sentence. Other criteria specific to the three situations were applied, as described below.

Multiple vs Unique Items/ Events. If pronouns refer conceptually, then pronouns that refer to multiple items or events should be paraphrased as plural nounphrases. For instance, the sentence pair

- a. I need a plate.
- b. Where do you keep them?

should be paraphrased as

17. Where do you keep your *plates*?

In contrast, a singular pronoun that refers to a unique item or event should be paraphrased as a singular nounphrase. For instance, the sentence pair

18a. I need an iron.

b. Where do you keep it?

should be paraphrased as

19. Where do you keep your *iron*?

To test this hypothesis, a blind judge counted the proportion of paraphrases in which subjects restated the pronouns as plural *vs* singular nounphrases. Paraphrases were counted only if the subjects specifically coupled the paraphrased plural *vs* singular nounphrase with the verb from the second sentence. For example, in order for the stimulus sentence pair (20a, b) to be counted as a plural paraphrase,

20a. I asked Jeff to go look for a light bulb.

b. But he couldn't figure out where I kept them.

it had to be paraphrased as

21. Jeff couldn't figure out where I kept the light bulbs.

Similarly, in order for the following sentence pair to be counted as a singular paraphrase,

22a. I asked Jeff to go look for a step ladder.

b. But he couldn't figure out where I kept it.

it had to be paraphrased as

23. Jeff couldn't figure out where I kept the step ladder.

This was in contrast to paraphrasing the sentence pair as

24. I asked Jeff to find the step ladder but he didn't know where to look.

or

25. I asked Jeff to find the light bulbs but he didn't know where to look.

So, only nounphrases that were preceded by the verb from the second sentence were counted. This criterion is obviously very conservative and possibly underestimates the incidence of true conceptual interpretation.

As shown in Table 2, the subjects were more likely to restate the pronouns as plural nounphrases (e.g. *plates*) when the target sentences contained plural pronouns (min $F'(1,28) = 6.252$) and were preceded by multiple items/events [min $F'(1,42) = 62.91$]. In contrast, as also shown in Table 2, the

subjects were more likely to restate the pronoun as a singular nounphrase (e.g. *iron*) when the target sentence contained a singular pronoun [$\min F'(1,31) = 28.36$] and was preceded by a unique item/event [$\min F'(1,32) = 70.47$].

Generic Types vs Specific Tokens. If pronouns refer conceptually, then pronouns that refer to generic types should be paraphrased as plural, indefinite nounphrases. For instance, the sentence pair

- 26a. My mother's always bugging me to wear a dress.
b. She thinks I look good in them but I don't.

should be paraphrased as something like

27. My mom thinks I look good in *dresses*...

or

28. My mom's always bugging me to wear *dresses*...

In contrast, a singular pronoun that refers to a specific token should be paraphrased as a singular, definite nounphrase. For instance, the sentence pair

- 29a. My mother's always bugging me to wear a dress that she bought me last year for Christmas.
b. She thinks I look good in it but I don't.

should be paraphrased as

30. My mom thinks I look good in *the/that dress that she bought me for Christmas*...

or

31. My mom's always bugging me to wear *the/that dress that she bought me for Christmas*...

To test this hypothesis, a blind judge counted the proportion of paraphrases in which subjects restated the pronouns as indefinite, plural nounphrases as opposed to definite, singular nounphrases. Again, this is a conservative estimate of conceptual interpretation.

As shown in Table 2, the subjects were more likely to restate the pronouns as indefinite, plural nounphrases (e.g. *dresses*) when the target sentences contained plural as opposed to singular pronouns [$\min F'(1,26) = 10.50$] and were preceded by generic types as opposed to specific tokens [$\min F'(1,20) = 33.92$]. In contrast, the subjects were more likely to restate a pronoun as a definite, singular nounphrase (e.g. *the dress*) when the target sentence contained a singular pronoun [$\min F'(1,22) = 16.84$] and was preceded by a specific token [$\min F'(1,21) = 49.98$].

TABLE 2
Paraphrase Data

	Pronoun	
	Plural (%)	Singular (%)
Multiple item/event nounphrase		
Multiple item interpretation <i>Where do you keep your plates? I need one.</i>	45	41
Unique item interpretation <i>Where do you keep your plate? I need it.</i>	1	6
Unique item/event nounphrase		
Multiple item interpretation <i>Where do you keep your irons? I need one.</i>	18	2
Unique item interpretation <i>Where do you keep your iron? I need it.</i>	21	48
Generic type nounphrase		
Generic type interpretation <i>My mom thinks I look good in dresses but I don't.</i>	63	59
Specific token interpretation <i>There's a dress my mom thinks I look good in but I don't.</i>	2	7
Specific token nounphrase		
Generic type interpretation <i>My mom thinks I look good in dresses but I don't.</i>	38	11
Specific token interpretation <i>My mom thinks I look good in the dress that she bought me last year for Christmas.</i>	32	61
Collective set nounphrase		
Collective set interpretation <i>The class didn't pay any attention to the substitute teacher.</i>	48	42
Individual member interpretation <i>A student didn't pay any attention to the substitute teacher.</i>	0	4
Individual member nounphrase		
Collective set interpretation <i>The students didn't pay any attention to the substitute teacher.</i>	19	1
Individual member interpretation <i>The student didn't pay any attention to the substitute teacher.</i>	17	49

Collective Sets vs Individual Members. If pronouns are interpreted conceptually, then pronouns that refer to collective sets should be paraphrased as groups of people performing animate actions. For instance, the sentence pair

32a. The substitute teacher begged the class to stop misbehaving.

b. But they didn't pay any attention to her.

should be paraphrased as

33. The *class* didn't pay any attention to the substitute teacher.

In addition, a singular pronoun that refers to an individual member should be paraphrased as an animate singular nounphrase. For instance, the sentence pair

34a. The substitute teacher begged the student to stop misbehaving.

b. But he didn't pay any attention to her.

should be paraphrased as

35. The *student* didn't pay any attention to the substitute teacher.

To test this hypothesis, a blind judge counted the proportion of paraphrases in which subjects restated each pronoun as a collective set (or group of individuals) as opposed to an individual. Paraphrases were counted only if the subjects specifically coupled the collective set nounphrase with the animacy verb from the second sentence. For example, sentence pair (32a, b) was not counted if it was paraphrased as

36. The substitute teacher wanted the class to shut up but they didn't.

Instead, the collective set nounphrase, *the class*, had to be the subject of an animate verb, such as *pay attention*, *stop misbehaving*, and so forth. Again, this leads to a very conservative estimate of conceptual interpretation.

As shown in Table 2, the subjects were more likely to restate the pronouns as collective sets performing animate actions (e.g. *the class didn't stop misbehaving*) when the target sentences contained plural as opposed to singular pronouns [$\min F'(1,26) = 10.50$] and when the target sentences were preceded by collective sets as opposed to individual members [$\min F'(1,20) = 33.92$]. In contrast, the subjects were more likely to restate a pronoun as an individual (e.g. *the student*) when the target sentence contained a singular pronoun [$\min F'(1,22) = 16.84$] and was preceded by an individual member [$\min F'(1,21) = 49.98$].

Discussion

The reading time data of Experiment 2 suggest that conceptual, though technically illegal, anaphors do not cause processing difficulties. One explanation of these data is that the heuristics for resolving anaphors are tested in parallel (Tyler & Marslen-Wilson, 1982). So, even though pronouns often violate lexical constraints, they fulfil pragmatic constraints. If heuristics are applied in parallel - perhaps in a horse-race fashion - then illegal plural pronouns would not disrupt comprehension.

The paraphrase data of Experiment 2 suggest that pronouns are indeed interpreted conceptually. When someone says "I need *a plate*" and then asks "Where do you keep *them*", comprehenders interpret the question as asking where multiple plates are kept. Similarly, when someone says that her mother always bugs her to wear "*a dress*" because "she thinks she looks good in *them*", comprehenders interpret the reason as the speaker's mother thinking the speaker looks good in dresses, in general. And when someone says that she needs to call the garage where her car is being serviced, comprehenders interpret that as the speaker needing to call the people who work at the garage, not the physical structure.

Both the reading time and the paraphrase data of Experiment 2 underscore the guiding role that pragmatic information plays in on-line comprehension. But how does pragmatic information guide comprehension? Perhaps comprehenders build mental or situational models that capture the real-world content of the text and make comprehenders' real-world knowledge accessible.

According to van Dijk and Kintsch (1983, pp. 11-12):

discourse understanding involves not only the representation of a textbase in episodic memory, but, at the same time, the activation, updating, and other uses of a so-called *situational model* in episodic memory: this is the cognitive representation of the events, actions, persons, and in general the situation, a text is about.

Indeed, van Dijk and Kintsch suggest that "if we are unable to imagine a situation in which certain individuals have the properties or relations indicated by the text, we fail to understand the text itself" (p. 337). Similarly, according to Johnson-Laird (1983), "the essential context of an utterance can be represented in a mental model, and the significance of the utterance is established by relating its propositional representation to this model and to general knowledge".

Garnham and Oakhill (1989) suggest that mental models have two functions: They provide both a representation of what the text is about and a model for understanding further text. They write: "Mental models are constructed incrementally. Each new sentence adds to the model, and the model so far provides (part of) the context for interpreting the next sentence" (p. 85).

Perhaps it is through these constantly updated mental models that pragmatic heuristics guide anaphor resolution. In other words, pronouns even illegal plural pronouns - are comprehensible because comprehenders establish and update mental models. For instance, someone reading the sentence

37a. I need a plate.

might assume that the speaker is in a typical, American household. Based on this assumption, the comprehender might create a mental model of this situation. If the comprehender's mental model is culturally schematic, it will embody the knowledge that most American households have more than one plate, and one plate is usually as good as another. Therefore, the comprehender's mental model enables a conceptual interpretation of the pronoun, *them*, in the question,

37b. Where do you keep *them*?

Someone reading the sentence

37a. I need an iron.

might also assume that the speaker is in a typical, American household, and might also build a mental model of the situation. However, if the comprehender's mental model is culturally schematic, it will contain the knowledge that most American households typically have only one iron, and that unique iron is being requested. So, in this case, the question

37b. Where do you keep *it*?

is easily interpreted.

The guiding role that real-world knowledge plays in interpreting pronouns and other conceptual anaphors can be demonstrated simply by changing the expectation that the speaker is in a house to the expectation that the speaker is in a department store. If a comprehender creates a mental model of this

department store, it will embody the knowledge that most department stores have more than one iron. So, the statement

38a. I need *an iron*.

refers to a multiple item/event instead of a unique item/event, and the comprehender's mental model enables an easy interpretation of the question

39b. Which aisle are *they* on?

However, the data presented here suggest that when comprehenders build mental models during comprehension, they do not represent each discourse entity with an iconic token. Rather, the data presented here support what Garnham and Oakhill (1988) suggested: Comprehenders only "introduce new elements into those models when they have to" (p. 734). In other words, comprehending the sentence

40a. My mother's always bugging me to wear *a dress*.

probably does not entail establishing in a mental model a single token that represents *one* dress. If it did, comprehenders would have difficulty with a plural pronoun, as in

40b. She thinks I look good in *them* but I don't.

Instead, comprehenders are more flexible. They can subsequently deal with plural pronouns that refer to generic types, such as *them* in (40b). Comprehenders can also deal with a singular pronoun that refers to a specific token, such as *it* in (40c).

40c. Yeah, *it's* the ugliest thing I've ever seen.

This flexibility could come about if comprehenders established tokens in their mental models only when required to (as suggested by Garnham & Oakhill, 1988).

In conclusion, illegal plural pronouns are not only considered natural but they are relatively easily comprehended. Although illegal plural pronouns are currently problematic for most artificial intelligence models of natural language processing, they demonstrate the conceptual nature of pronominal anaphora: Conceptual anaphors provide more than verbal shorthand; they do more than simply save a speaker's breath or a writer's pen. They allow extension, and they enable speakers and writers to reference the world.

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