Number is one of a small set of basic conceptual categories with relatively clear grammatical reflections and requirements. It must be called upon during fluent language production to create agreement between subjects and verbs, and the questions addressed in this paper concern how that is done. The number information that is used may be notional (whether the referent of the subject noun phrase is single or multiple), or lexical (whether the subcategorised number of the head of the subject noun phrase is singular or plural), or even morphophonological (whether the head of the subject noun phrase has the phonological features associated with plural inflections). Different views about language processes make contrasting predictions about the likelihood of contributions from each of these sources during normal speaking. In a series of experiments employing an agreement-error elicitation task, we examined the effects of variations in notional, lexical and morphophonological features on the implementation of agreement. The results suggest that verb agreement is dominated by lexical number.

INTRODUCTION

Subject–verb agreement offers a window onto an interesting component of the mapping from thought to language. In the languages of the world, the categories of agreement seem to reflect basic categories of experience and social interaction, including number, person, gender, power and solidarity. In English, the linguistic dependency represented in subject–verb number agreement exemplifies one of the classic explanatory problems in psycho-
linguistics, because it may span stretches of speech that can only be defined in abstract structural terms. So, the subject of a clause agrees with its verb even when the noun phrase that carries or marks subject number is separated from the verb by material that may be of indeterminate length or complexity.\(^1\) The study of the implementation of agreement in speech thus offers a glimpse of how speakers cast fundamental conceptual distinctions into fundamental linguistic relationships.

Since relatively few structural dependencies are marked in English, syntactic relationships are rarely cued by overt elements. Subject–verb agreement is an exception, because the number of the verb must agree with the number of the subject noun phrase. This agreement is not always explicit, but it is signalled by variations in the third-person present forms of most verbs (compare the third-person singular *climbs* with the third-person plural *climbs*) and, for the irregular verb *to be*, by variations in the first and third person in both the present (*am, is, are*) and past (*was, were*).

To reliably mark subject–verb agreement, speakers must prepare utterances in such a way that the form of the verb can be adjusted in accordance with the number of the subject. This means, first, that there has to be a processing link between the subject and the verb and, secondly, that there has to be a representation of information about the number of the subject that is transmitted over that link. In an effort to analyse these components of the agreement process, we have been studying agreement errors (Bock & Cutting, 1992; Bock & Miller, 1991), following in the long tradition of using speech errors to illuminate language production (see, among many others, Cutler, 1982, 1988; Deese, 1984; Dell & Reich, 1981; Fromkin, 1971, 1973; Garrett, 1975, 1988; Levelt, 1983; Meringer & Meyer, 1895/1978; Shattuck-Hufnagel, 1987; Stemberger, 1983a, 1985a) and in the more recent tradition of eliciting such errors under experimental control (e.g. Baars, Motley, & MacKay, 1975; Dell, 1986; 1990; Stemberger & MacWhinney, 1986).

The mistakes that interest us are called errors of attraction in the traditional literature (e.g. Strang, 1966). The utterance “The readiness of our conventional forces are at an all-time low” is illustrative. In it, the head subject noun phrase (“The readiness”) has a post-modifier containing another noun phrase, the local noun (“forces”) that disagrees with the head in number. The additional samples in Table 1 reveal some of the regular features of attraction. One is that the errors are more common after plural than after singular local nouns. This is true in both observed and experimentally elicited errors: between 80 and 90% of the errors follow plurals (Bock & Miller, 1991). We assume that this is because a

\(^{1}\text{How length and complexity affect the implementation of agreement will not be considered in this paper, but is examined by Bock and Cutting (1992).}\)

<table>
<thead>
<tr>
<th>Error</th>
<th>Head Noun</th>
<th>Local Noun</th>
<th>Verb Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>We know what the result of the 1930s were</td>
<td>result</td>
<td>1930s</td>
<td>were</td>
</tr>
<tr>
<td>Membership in these unions were voluntary</td>
<td>membership</td>
<td>unions</td>
<td>were</td>
</tr>
<tr>
<td>Disputes over health coverage was the cause</td>
<td>disputes</td>
<td>coverage</td>
<td>was</td>
</tr>
<tr>
<td>The only generalisation I would dare to make about our customers are that they're pierced</td>
<td>generalisation</td>
<td>customers</td>
<td>are</td>
</tr>
</tbody>
</table>

singular verb is the processor's default value, which is normally blocked by a plural head and occasionally blocked by a plural local noun. A second feature of the errors in Table 1 is the involvement of the irregular forms of *to be*. This is a joint consequence of the frequency of these forms and the fact that only these forms mark number in the past tense (the most common tense in English narrative; Svartvik, 1966). We will return to these points in the General Discussion.

In the experiments that we report below, we were concerned with the nature of the information that controls the number of the verb. One hypothesis is that verb number is directly under the control of the same sort of information that determines the number of the subject. With various exceptions that we will catalogue later, subject number commonly reflects notional number (the number in the speaker's intended message). If the same is true of verb number, singular number on verbs may reflect notional singularity, and plural number on verbs may reflect notional multiplicity (Pollard & Sag, 1988). If so, we would expect to see some influence of number meaning on verb marking.

A very different hypothesis suggests that verb number may be under the control of, or at least influenced by, the overt morphophonological marking of noun number. In English, plural noun on the vast majority of nouns is marked by one of the allomorphs of the plural, *-s/, *-z/, or *-z/. The frequency and regularity of this marking in the experience of speakers, in conjunction with variations in verb morphology, could support the development of a processing heuristic by which the presence of a plural (or plural-like) suffix on a noun triggers a complementary verb form. Such a heuristic would be expected to arise within any processing system that is sensitive to correlated features in the input, as in various connectionist models of language processing (McClelland, 1987). A heuristic along these lines has been invoked to explain the features of one class of morphological errors in child and adult speech (Stemberger & MacWhinney, 1986).
These expectations stand in contrast to a more traditional view of the determinants of verb number. On that view, verb number is derivative or conditional on subject number and carries no meaning on its own (e.g., Padučeva, 1973). It does not reflect singular or plural meaning, but only the abstract indexation of the subject as singular or plural, based on the subcategorisation features of the word that heads the subject noun phrase. On this argument, the information that controls verb number may have a strictly linguistic character. If this is so, we would predict effects of subcategorised number, but not of notional number or the phonological correlates of plural number, on verb agreement.

These contrasting predictions run along lines of division that are familiar in psycholinguistic inquiry. Within a language-processing system that is simultaneously attentive to the semantic, phonological and syntactic properties of words and sentences, one would expect to see effects of plural meaning and plural “sound” on number marking. Those effects might be especially in evidence when errors occur, if conflicting semantic or phonological information serves to disrupt normal agreement patterns. Alternatively, within a language-processing system whose operations are highly differentiated with respect to the kinds of information to which they are sensitive, with some operations attentive only to notional properties, some only to phonological properties and others only to syntactic properties, effects of number meaning and number sound on agreement marking are not assured. If agreement is normally implemented with respect to subcategorical rather than notional or phonological distinctions, and if disruptions to agreement are similarly confined to subcategorical rather than notional or phonological conflicts, formal number distinctions may be all (or nearly all) that matters.

Before we can get at this issue, we need to consider what counts as a plural in English. That is a surprisingly complicated matter, and what counts as a plural with respect to agreement marking is correspondingly complex. After we review some of the problems in the analysis of plurality and some of the findings from previous work that are relevant to those problems, we report a series of experiments designed to analyse the nature of the noun-number information that is used to determine the number of the verb.

**NUMBER MEANING AND NUMBER MARKING**

The imperfect reflection of notional number in number marking is evident in an array of facts about English. We will consider three different sets, one having to do with plural marking on nouns, another with the relationship between the number of the subject and the number of the verb, and a third with the relationship between subject number and anaphor number for anaphors that have the subject as their antecedent.

**Notional Number and Nominal Number**

The relationship between number in the world and English plural marking is far from transparent. Some familiar examples include cases in which number in the world is arguably singular when number in the language is plural. A large class of nouns with this property consists of summation plurals such as *binoculars, scissors, trousers* and *glasses*. Though it is usually the case that the objects these words denote have two joined symmetrical parts (Quirk, Greenbaum, Leech, & Svartvik, 1972; 1985), some objects with joined symmetrical parts do not belong to the class (e.g. *shirt, jacket*). Uncertainty about whether the objects denoted by words in this class are property plural can be found in backformations by both children (Mervis & Johnson, 1991) and adults. An illustration comes from some instructions that accompanied a pair of binoculars from the Scope Instrument Corporation of Harrison, N.Y. The instructions, entitled “Care of Your Binocular”, admonished: “Your binocular is a precision instrument and should be treated in the same way as a fine watch or camera. When not in use, it should be put back into its case” (italics added).

Other nouns do not change their singular form even when the number of objects to which they refer is plural. These are the invariant or unchanging singulars (*deer, sheep, salmon*), which may denote either one thing or more than one. Less often remarked is a productive plural use of the singular forms of certain nouns which have regular plurals, often game animals such as *bear* (as in “There were two bear in there fishing”; cited by Hirtle, 1982, p. 20; also see Allan, 1976).

In still other cases, number in the world may be plural when number in the language is singular. Collective nouns such as *army, fleet* and *committee* refer to multiple objects, and in that sense are plural, despite their singular form. We will call this sense the *distributive* collective. However, collectives also carry a singular meaning that corresponds to the notion of a single grouping (for which there are plural forms, as in *armies, fleets* and *committees*). We will call this single-group sense the *wholistic* collective. The phenomena of verb and anaphor agreement, to which we now turn, provide evidence that this collective duality is far from simple.

**Notional Number, Noun Number and Verb Number**

One problem that collectives pose is that it is difficult to discern a consistent relationship between verb number and the wholistic vs distributive meanings of collectives. Though speakers are eager to rationalise their use of plural or singular verb forms after collectives in terms of “thinking about the whole” vs “thinking about the parts”, our observations suggest...
that most speakers of English in the U.S.A. use singular verbs with most
collectives most of the time. Notable exceptions are the collectives people,
cattle and police, which seem to be invariably plural for the purposes of
agreement, and a few words like clergy and faculty, for which agreement is
more variable.

Speakers of British English are more willing to employ plural verbs with
collectives (Johansson, 1979). Jespersen (1954) suggested that this is
particularly true for animate or "corporate" collectives, and Quirk et al.
(1972) noted that it may be more common in speech than in writing. The
difference is illustrated in the following observed uses of family, the first
from an American and the second from a British speaker:

1. The family is approached [by a physician]...
2. I don't think the royal family are really known for their intelligence.

Particularly jarring to the stateside ear is plural agreement with subjects
such as government, company, and so on, as in Prime Minister John
Major's assertion that "I understand the pressure that the Israeli
government are under" (19 January 1991). At least on the surface, these
eccentricities in the distribution and use of plural agreement with collectives are
hard to square with thoroughgoing notional accounts.

Verb agreement after other types of expressions also indicates the
unreliability of the relationship between agreement marking and the
notional number of the subject. Morgan (1984) adduced several cases in
which formally plural noun phrases are treated as singular for purposes of
agreement (e.g. Forty acres is too much to plow in one day; Peacock eggs
with lemon butter is delicious), presumably because a holistic interpretation
dominates. But from the other side, Morgan marshalls examples in
which formally singular and formally plural noun phrases are treated as
singular and plural for purposes of agreement, even though their notional
number is the opposite (e.g. More than one student has passed the exam; Fewer
than two students have failed the exam).

Verb Agreement and Anaphoric Agreement

The apparent duality of collectives with respect to verb-number marking is
also reflected in contrasts in the behaviour of different kinds of agreement
markers. Consider "The committee is going to meet tomorrow. They will
decide which candidates to invite then." Note that the collective committee
takes a singular verb form in the first sentence, but serves as the antecedent
for the plural pronoun they in the subsequent sentence. Similarly, after one
of the utterances cited above ("The family is approached [by a physician]..."), the speaker referred to the family with a plural pronoun
("they..."). Gernsbacher (1991) has shown that people judge plurals as
more natural anaphors for collectives, and that they read sentences with
plural anaphors for collectives more rapidly than the same sentences with
singular anaphors.

If it is the semantics of words such as committee and family that drives
their grammatical behaviour, it seems that speakers may not operate with
the same meaning from one sentence to the next. Alternatively, it may be
that the information that controls verb-number agreement is different from
the information that controls anaphor-number agreement.

Summary

This brief review of some of the phenomena of number marking in English
establishes that the relationship between number meaning and number
marking is neither entirely regular nor entirely simple. Some inconsistencies
are apparent in the distribution of the nominal plural inflection itself,
but the irregularities become even more pervasive when agreement sys-
tems come into play. In the next section, we describe some previous work
on number agreement which was designed to examine its links to notional
plurality, as those links might be revealed by agreement errors.

THE MEANING BEHIND NUMBER AGREEMENT:
SOME EVIDENCE FROM ATTRACTION

In previous experiments on attraction, Bock and Miller (1991) were
interested in several issues that bear on the present studies. One of them
was whether subject-relevant semantic properties of the local noun
influence the occurrence of errors. Two such properties are animacy and
concreteness, both of them prototypical features of the arguments of the
subject relation (Bates & MacWhinney, 1982). Bock and Miller compared
the incidence of verb-number errors after subject phrases with local nouns
that were either animate (The island of the kings) or inanimate (The king of
the islands) and higher or lower in concreteness. The speakers' task was to
continue the subject phrases with material that made them into complete
sentences. In performing this task, the speakers typically produced a verb
immediately after the local noun, and this verb sometimes disagreed in
number with the head noun.

Relative to control conditions in which the number of the local noun was
the same as the number of the head, there were no more errors after
animate than inanimate local nouns, or after concrete than abstract local nouns. However, when the head and local nouns mismatched in number, there were substantially more errors after local plurals than local singulars, regardless of their animacy or concreteness. This suggests that agreement errors are not so much a product of spurious subject identification (i.e. taking the local noun to be the head) as of spurious number transmission (i.e. the power of a plural noun over a neighbouring verb). Bock and Cutting (1992) have shown that this transmission is weakened by the presence of a clause boundary between the local noun and the subsequent verb, so locality must be defined hierarchically, as well as serially.

The implication is that local plurality somehow disrupts normal agreement. Bock and Miller (1991) examined one meaning-based explanation for this disruption, drawing on the idea that the number of the verb may be controlled by numerosity in the speaker's referent model (Keenan, 1974; Pollard & Sag, 1988). The number in the referent model, which corresponds to the speaker's conception of the situation denoted by the entire subject phrase (including the postmodifier), can differ from the subcategorisation-based number of the phrase. For example, in the referent model, a subject phrase such as The letter from the lawyers will include just one letter, so that the notional number is the same as the subcategorised number of the head noun. However, for a subject phrase such as The picture on the postcards, the referent model should include several postcards with the same picture, making the notional number different from the subcategorised number.

Bock and Miller compared notionally and subcategorically singular subject phrases (such as The letter from the lawyers) with notionally plural but subcategorically singular subject phrases (such as The picture on the postcards) in their likelihood of eliciting agreement errors. There was no difference in the number of errors, nor was there any correlation between the occurrence of errors and judgements of numerosity in the referent model. Although the judgements very strongly reflected the differences in notional number, these differences were unrelated to the occurrence of errors. Instead, the errors seemed to be under the control of the number of the local noun.

Although this result suggests that one sort of notional plurality—plurality in the referent model—may have little impact on the occurrence of agreement errors (and on verb-number agreement in general), the effects of other notional correlates of number remain to be investigated. If these should also turn out to be unrelated to agreement in any systematic way, at the same time that contrasts in subcategorical number remain strongly related to agreement, the case for a lexical account of the structural dependency in subject–verb number agreement would be solidified.
apply when they “find themselves” already instantiated in the developing string.

Used across consecutive words rather than within consecutive syllables, such mechanisms could support the normal, correct implementation of agreement in English (though not in such languages as Dutch and German, where the plural on the noun and verb can be the same), and do so with no reference to the meanings of the words involved. Moreover, the same mechanism would elegantly explain the distribution of attraction errors. When the local noun is plural, the correct verb form often requires repeating the ending of the noun (as in *The king of the island*’s rule*iz*’), and in the most common error form, the second inflection is left off (as in *The king of the island*’s rule). So attraction errors may simply be the by-product of a normal, phonologically or morphophonologically based mechanism that supports subject–verb agreement (Strang, 1966; Zandvoort, 1961).

A PREVIEW OF THE EXPERIMENTS

The experiments were designed to explore the processing underpinnings of verb-number agreement in English, focusing on the contributions of the lexical, notional and morphophonological factors just reviewed. We employed the same sentence completion task as Bock and Miller (1991), in which prescribed noun phrases served as the subjects of sentences that the speakers generated. The experimental noun phrases contained a head noun phrase followed by a prepositional phrase, with a local noun that matched or mismatched the head in subcategorised number. After hearing each of these preambles, the speaker repeated it and continued on with material that turned the preamble into a complete sentence. Typically, the verb immediately followed the local noun, and we examined whether it agreed or disagreed with the number of the head noun.

The first question to be explored was whether or to what degree the phonology or morphophonology of the plural supports or, in the case of errors, interferes with agreement. To assess this, in the first two experiments we looked to see whether the incidence of error changed after singular local nouns whose endings were matched to the endings of true plurals in their phonology. If there is a phonologically based mechanism that contributes to normal agreement, we would expect to see more agreement errors after singulars that phonologically resemble plurals than after phonologically unambiguous singulars.

The third experiment addressed the regularity of noun-number marking. Some English nouns (e.g. *feet, children*) are irregularly marked. If the form of the nominal plural inflection itself affects verb agreement in some way, irregulars should behave differently from regulars. However, if it is the meaning or subcategorical marking of plurality that controls agreement, there should be little difference between irregular and regular forms.

In the last experiment, we turned to the role of notional number in implementing agreement. If the number marking on verbs is influenced by the meaning of the plural, we would expect to see more errors after collective local nouns than after matched singular local nouns. Conversely, if verb-number inflection is driven by a lexical stipulation or subcategorisation of number (traditional grammatical number), the overriding influence should come from local nouns whose number is marked as plural.

The assumption behind this work, as in other studies of speech errors, was that the factors responsible for the errors are closely related to the factors that affect normal, error-free language production (Fromkin, 1971). We are therefore supposing that when a local noun attracts agreement to itself, it does so because it possesses properties that normally control subject–verb number agreement. Since other work indicates that plurality is one of these properties, most of the experiments below focus on plural number and its marking. However, in Experiment 3 we also examined the ability of a type of singular noun (called *locally marked* by Tiersma, 1982) to attract agreement.

EXPERIMENT 1

Method

Participants. Thirty Michigan State University undergraduates took part in the experiment in exchange for extra credit points in an introductory psychology course. All of them were native speakers of English.

Materials. The experimental preambles are illustrated in Table 2. There were three versions of each of 30 base preambles, all of them containing a singular head noun followed by a prepositional phrase that ended with the local noun. The only differences between the three versions of each preamble occurred in the local noun. The pseudoplural version contained a singular monosyllabic noun whose final phonological segment was either /s/ or /z/. The local noun in the singular control version was also a monosyllabic singular noun that shared all of the phonological segments of the pseudoplural local noun except the last segment, which was never /s/ or /z/. The local noun in the true plural version was the

3In two items, the identity of the vowels in the pseudoplural and control nouns depended on the dialect of the speaker. These items contained a contrast like the one in the words *caught* and *cor*, which is present in some dialects of English (including the dialect of the second author) but not in others (including the dialect of the first author).
plurals, with non-syllabic inflection whose phonological form matched that of the last segment of the pseudoplural local noun. All of the experimental preambles are listed in the Appendix.

In addition to the experimental preambles, there were 56 filler preambles. All were simple noun phrases, half with a determiner–adjective–noun sequence and the other half with a determiner–noun sequence. Overall, 23 were singular and 33 plural, with singulars and plurals represented proportionately within the two sequence types.

Three lists were constructed from these materials. Each contained all 56 fillers and 30 experimental preambles, one from each of the 30 sets, for a total of 86 items. Each experimental preamble-type (pseudoplural, singular, true plural) was represented 10 times on every list, each time derived from a different base preamble. Across the three lists, every version of every experimental preamble occurred just once. In each list, taking the filler and experimental preambles together, half of all the preambles contained a plural noun phrase; among the head noun phrases, 53 were singular and 33 were plural.

Every list began with a random arrangement of eight filler preambles (four singular and four plural). The remaining filler and experimental preambles were randomly distributed throughout the list with the constraint that no experimental items could occur consecutively. The fillers were in the same order across the three lists, as were the experimental items from the same sets.

Sound-editing software (MacSpeech Lab II, GW Instruments) was used to record all of the preambles digitally. The preambles were read by a female speaker (K.E.) and digitised at a sampling rate of 20 kHz. Each preamble was then edited using a visual display of the waveform accompanied by audio playback. The editing deleted silent intervals and portions of long continuants in order to create a faster rate of speech that remained completely natural and perceptible. The preambles were then reconverted to analogue form and recorded on audio-cassette tape in the order appropriate for each list.

**Procedure.** The participants were run individually. They were informed that they would hear phrases which they were to make into full sentences, using each phrase as the beginning of the sentence. They were asked to repeat each phrase and then complete it as quickly as possible, speaking as rapidly as possible, to form a single sentence. They were given no other instructions about the forms of the completions.

On every trial, the experimenter played a single preamble and then paused the audio tape. This cued the participant to repeat the preamble and complete it. If the participant failed to apprehend the preamble, the experimenter repeated it. The experimenter also encouraged the participants to speak faster or to make their completions quicker if these rates slowed appreciably during the experiment. The experimental sessions, each lasting approximately 20 min, were recorded on audio tape.

**Scoring.** The repetitions and completions of the experimental preambles were transcribed from the audio tape and classified into one of four categories. A **correct** was scored if the speaker's response contained only one repetition of the preamble that was complete and correct, if the preamble repetition was immediately followed by a verb form that was overtly inflected for number (all third-person present-tense forms and the past-tense forms of to be), if the inflection was correct with respect to the subcategorised number of the preamble's head, and if the response constituted a complete sentence. An **error** was scored if the response met all of the criteria for a correct except that the number inflection of the verb was wrong with respect to the number of the preamble's head. Responses were classified as **ambiguous** if they met all of the criteria for a correct except that the finite verb form (the part of the verb that carried number and tense) was not a form that undergoes number variations (e.g. most past-tense verbs). Although ambiguous responses are superficially correct, they carry the possibility of latent, undiagnosable agreement errors, and so were treated as a separate category.

Any sentence that did not meet the criteria for one of the above three categories was considered a **miscellaneous** response. Most of these contained two or more preamble repetitions or had errors in the repetition (e.g. "The condition for the race" repeated as "The conditions for the race"). In other cases, the completion included no verb or a verb that was
separated from the local noun by other words (e.g. “The purpose of the kiss because he loved her”).

If two verb forms were produced in succession (as in a self-correction), only the first was considered in the scoring. There were no self-corrections that changed the number of the first verb produced (so the speakers never corrected their agreement errors).

Application of these criteria yielded 667 corrects (74.1% of all completions), 31 agreement errors (3.4%), 144 ambiguous (16.0%) and 58 miscellaneous responses (6.4%).

**Design and Data Analysis.** Every speaker received 10 different items in each of the three local-noun conditions (pseudoplural, singular and true plural) and every item was presented to 10 different speakers in each of the same three conditions.

All statistical analyses were performed once with speakers and again with items as random factors. The test statistics for these analyses are designated $F_1$ and $F_2$, respectively. The alpha level in this and all other experiments was set at 0.05.

**Results**

Table 3 gives the number of responses in each scoring category in each condition. The most revealing results were those for the agreement errors. All 31 occurred when the local noun was a true plural. There were no agreement errors at all in either the pseudoplural or the singular control conditions.

The correct responses were distributed in a complementary fashion, with singular and pseudoplural–singular local nouns both yielding more corrects than the true plurals. The differences among the conditions were significant in a one-way analysis of variance with participants $[F(1,58) = 6.09]$ and with items random $[F(2,58) = 5.98]$. Similar analyses revealed no reliable differences for either the ambiguous $[F(1,58) = 0.34; F(2,58) = 0.43]$ or the miscellaneous responses $[F(1,58) = 2.47; F(2,58) = 2.33]$.

Examination of the miscellaneous responses revealed five agreement errors (errors with respect to the form of the preamble that the speaker actually produced, rather than the presented form). None of these errors followed pseudoplural local nouns. Three of them followed true plurals, and the other two occurred after preambles that were miscast with plural heads.

**Discussion**

The phonological correlates of plurality failed to create attraction errors. There was no tendency for errors to occur after singular local nouns that ended in the same sounds as plural forms (as in course vs courts). In fact, no errors occurred after the pseudoplural singular nouns, and correct agreement was just as common after the pseudoplural singular as after the unambiguous singular local nouns. These findings are inconsistent with a phonological contribution to agreement control, and with our hypothesis about phonological influences on agreement errors.

**EXPERIMENT 2**

Although we failed to find any evidence for phonological conditioning of agreement errors in the preceding experiment, there is an alternative morphophonological hypothesis that could help to account for them. Even if attraction errors do not reflect the brute phonological co-variations found in subject–verb number agreement, they might respond to those co-variations when local nouns respect the relevant morphophonological constraints. In Experiment 1, the pseudoplurals were, for the most part, plural-like only in having the same final consonant as their matched true plurals. However, they did not obey the morphophonological rules that govern plural formation: The sequence of sounds that forms the word course (/kɔːrs/) is not the plural of a stem which contains the sequence of sounds /kɔː/ (cf. the word core); the plural form of that stem is /kɔːz/.

A minor obstacle to testing the morphophonological hypothesis is that many singular words that are morphophonologically possible plurals (e.g. tax) have true plural homophones (tacks), making it impossible to present the materials auditorily. However, with visual presentation, this obstacle becomes an advantage, since we can equate the phonology of the full forms...
of the true plural and pseudoplural singular words, not just their endings. In the second experiment, we constructed preambles with pairs of pseudoplural and true plural local nouns that were phonologically matched across all segments (e.g. hose-hoes, clause-claws, raise-rays). The singular of the true plural served as the control form.

Method

Participants. Twenty-four Michigan State University undergraduates participated in the experiment in exchange for extra-credit points in introductory psychology courses. None of the students had taken part in the first experiment. All of them were native speakers of English.

Materials. The experimental materials consisted of 12 sets of three preambles like those used in the first experiment. The only differences among the members of each set were found in the local nouns. The pseudoplural local nouns were monosyllabic singulars (e.g. cruise) that have phonologically identical but orthographically different plural homophones. The true-plural local nouns were the homophones themselves (e.g. crews), and the singular local nouns were the singular forms of the true plurals (e.g. crew). Table 2 gives an example of the preambles, and the Appendix lists the full set.

Fifty-six filler preambles were also constructed. Half were determiner-adjective-noun sequences and half determiner-noun sequences. In each type, 11 of the preambles were singular and 17 were plural.

Three 68-item lists were constructed from these materials. Each list contained 12 experimental preambles, one from each of the 12 sets, and all 56 fillers. Each experimental condition was represented by four experimental preambles on every list. Across the three lists, every experimental preamble occurred once. Within each list, half of all the preambles had singular and half had plural head nouns.

The order of the items in the lists was as described in Experiment 1.

Procedure. The participants were run individually. They were informed that they would see phrases in the centre of a computer screen, one at a time. They were instructed to read each phrase aloud and then continue on with a completion for the phrase, turning it into a complete sentence as quickly as possible. They were also asked to speak as rapidly as they could.

The participants were seated in front of a Macintosh 512K computer. The preambles were displayed in 12-point Chicago font, centred on one line in the middle of the screen. The first letter of the first word of each preamble was capitalised, but no other punctuation was used. The experimenter triggered the presentation of a preamble by pressing a key on the keyboard. As soon as the participant read aloud the final word of each preamble, the experimenter cleared the screen. The screen remained blank until the participant finished his or her response.

All the experimental sessions were recorded on audio tape. Each session was approximately 15 min long.

Scoring. The responses were transcribed and scored in the same way as in the first experiment. There were 171 corrects (59.4% of all responses), 21 agreement errors (7.3%), 61 ambiguous (21.2%) and 35 miscellaneous responses (12.1%). Again, there were no self-corrections that resulted in a change in the number of the produced verb.

Design. Each speaker completed four preambles in each of the three local-noun conditions, and each item was completed by eight speakers in each of the same three conditions.

Results

Table 3 shows that all 21 agreement errors again occurred after preambles with true plural local nouns. The distribution of correct responses was roughly the opposite, with the true plurals yielding the fewest corrects. A one-way analysis of variance in the correct scores was significant with participants random \( F(2,46) = 8.87 \) and marginal with items random \( F(2,22) = 3.18, P = 0.06 \). Pairwise planned comparisons revealed that the differences between each of the singular conditions and the plural condition were significant in the participants analysis, but the difference between the two singular conditions was not (the confidence interval for these comparisons was 10.3). In the items analysis, the confidence interval was wider (21.1), and only the difference between the true plurals and the pseudoplurals reached significance.

The condition differences were not significant in the analyses of the ambiguous \( F(2,46) = 1.22; F(2,22) = 0.07 \) or the miscellaneous responses \( F(2,46) = 2.30; F(2,22) = 1.27 \). There were seven agreement errors among the miscellaneous responses, all of them occurring after true plural local nouns.

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*Because the duration of the inflection on a true plural may be slightly longer than the final segment of a singular homophone (Walsh and Parker, 1983, measured a 9-msec difference), the spoken forms may not be fully identical.
Discussion

The second experiment, like the first, offered no evidence for phonologically conditioned agreement errors. Once again, all errors of agreement involved true plural local nouns, and speakers were as reliable in marking agreement correctly after pseudoplural singulars as after unambiguous singular local nouns. There was a small difference between the pseudoplural singular and the unambiguous singular condition in correct agreement performance, but the direction of this difference was inconsistent with the morphophonological hypothesis. Rather than reducing the number of correct (singular) responses, pseudoplurality in the local noun slightly increased it, albeit not reliably.

The proportion of agreement errors for true plurals was larger in this experiment than in Experiment 1. Since the true plurals themselves were not different in any obvious ways, a more plausible reason for the difference is the presentation modality. It may be that after visual presentation, the speakers maintained less information about the presented order of the head and local noun than after auditory presentation, a possibility that gains credence from a doubling of the percentage of miscellaneous responses from the previous to the present experiment. Along related lines, Jakimik and Glenberg (1990) showed that with visual presentation, speakers had more trouble determining the antecedents of temporal anaphors (e.g., former, later) than with auditory presentation, extending to language comprehension a temporal order disparity found in studies of list learning (e.g., Glenberg & Fernandez, 1988).

However, if this explanation is right, it must be that speakers sometimes did not use their actual reproductions of the presented preambles as the beginnings of the sentences they created. Since all of the correctly and incorrectly agreeing verbs followed correct preamble reproductions, the disparity in error frequency cannot be attributed to a simple difference in the immediate recallability of the preambles. It may be that the speakers sometimes fell back on episodic traces of the presented preambles in constructing their sentences, and made errors because of faults in those traces that were not present in their reproductions.

EXPERIMENT 3

Experiment 3 was conducted as a final effort to determine whether something about the morphology of the regular plural marking on a noun contributes to agreement marking. If there is any validity to this hypothesis, the regular forms of the plural (e.g., kids) should be more reliably associated with the implementation of number agreement than irregularly marked plural forms (e.g., children). However, if it is the more abstract conditions behind the overt marking of plurality that reliably trigger number agreement operations, both regular and irregular plurals may elicit agreement errors. To test this, we compared the rates of agreement errors after irregular-plural local nouns with the rates after a semantically matched regular plural. In both cases, the rates were assessed relative to the number of plural-verb errors that occurred after the singular forms of the nouns.

In this experiment, we also added conditions designed to assess the occurrence of attraction errors for singular local nouns following plural heads. So, in addition to such preambles as The trap for the mice, we included The traps for the mice along with regular (The traps for the rat) and control (The traps for the mice; The traps for the rats) forms. Tiersma (1982) argued that certain irregular plurals in English have survived because they refer to things that customarily occur in groups, making their singularity the less usual forms. In this respect, they differ from words with regular plurals, for which the singular is more usual. If the asymmetry between singulars and plurals in the elicitation of attraction errors is due to the atypical status of the regular plural, Tiersma’s hypothesis suggests that the singular forms of nouns that participate in irregular plural paradigms should be more likely to create attraction errors than the singularity of nouns from regular plural paradigms.

The number of items in this experiment was small because there are surprisingly few irregularly marked plurals that are likely to be familiar to the average undergraduate. We excluded comparatively obscure pairs (such as die–dice, louse–lice and corpus–corpora), pairs in which the number of the plural member is often misconstrued (e.g., phenomenon–phenomena and criterion–criteria), and pairs which undergo only a voicing adjustment on the final consonant before adding a regular plural affix (e.g., calf–calves, leaf–leaves, wife–wives) and thereby retain the phonological correlates of the regular singular–plural alternation. We did not use compounds formed from roots already represented among our materials (e.g., policeman). Finally, we did not use zero-marked plurals (e.g., sheep, salmon, deer) because the manner in which the number of these nouns is interpreted may be very different from that of number-marked nouns. This left just eight candidates: goose–geese, man–men, woman–women, child–children, foot–feet, mouse–mice, tooth–teeth and ox–oxen. All of these pairs were listed by Tiersma (1982) as cases in which the plural may be the more typical form. In five of the eight, the plural is indeed more frequent, according to Francis and Kučera (1982). The singular and plural of mouse and mice are equal in frequency, and man and woman are more frequent than their plurals.
Method

Participants. Ninety-six Michigan State University undergraduates participated in this experiment in exchange for extra-credit points in introductory psychology courses. None of them had taken part in the previous experiments, and they were all native speakers of English.

Materials. The experimental materials consisted of eight sets of eight preambles each. An example of a single set is shown in Table 4, and all the sets are listed in the Appendix. As before, all the preambles consisted of a head noun followed by a prepositional phrase ending with a local noun. In each set, the head noun was plural in half the preambles and singular in the other half. For each head-noun number, half of the local nouns were singular and half plural; and of the plurals, half were regular and half irregular. The irregular-plural-forming nouns were matched with regular-plural-forming nouns with related meanings and the same number of syllables (man-boy, mouse-rat, foot-hand, goose-swan, child-kid, woman-lady, ox-horse, tooth-mouth).

There were also 22 filler preambles, half singular and half plural. Each filler type included some preambles with a determiner-noun sequence and others with a determiner-adjunctive-noun sequence.

All the preambles were digitally recorded and edited following the methods described in the first experiment, and then analogue-converted and recorded onto audio tape in the sequence prescribed by the list arrangement.

There were eight lists. Each contained all 22 fillers and eight experimental preambles, one representing each of the eight items. Every experimental condition was also represented by one preamble on every list. Across all eight lists, every experimental preamble occurred just once. The items in the lists were ordered as in the earlier experiments, with eight fillers at the beginning followed by a quasi-random arrangement of filler and experimental items. The same order was used in every list.

### Table 4

<table>
<thead>
<tr>
<th>Local Noun</th>
<th>Singular Subject</th>
<th>Plural Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irregular, singular</td>
<td>The trap for the mouse</td>
<td>The traps for the mouse</td>
</tr>
<tr>
<td>Irregular, plural</td>
<td>The trap for the mice</td>
<td>The traps for the mice</td>
</tr>
<tr>
<td>Regular, singular</td>
<td>The trap for the rat</td>
<td>The traps for the rat</td>
</tr>
<tr>
<td>Regular, plural</td>
<td>The trap for the rats</td>
<td>The traps for the rats</td>
</tr>
</tbody>
</table>

Procedure. The procedure was the same as in the first experiment.

Scoring. The scoring criteria duplicated those of the previous experiments. There were 529 responses scored as corrects (68.8% of the total), 26 as agreement errors (3.4%), 161 as ambiguous (21.0%) and 52 as miscellaneous (6.8%).

Design. Each of the 96 participants received one preamble in every one of the eight conditions formed by the orthogonal combinations of three factors. The factors included the number of local noun (singular or plural), the match in number between the head and the local noun (mismatch or match), and the type of local noun (irregular or regular).

Results

The numbers of responses of each type in each of the eight experimental conditions are given in Table 5. The table shows that the mismatch condition yielded fewer correctly agreeing verbs and more errors than the match condition, that plural local nouns were less often associated with correct agreement than were singulurs (although among the errors, this occurred only in the mismatch conditions), and that the distribution of these responses was very similar for the regular and irregular forms. Most of these differences were confirmed statistically in analyses of variance on the correct responses. There was a significant main effect of the match between the head and local noun $[F(1,95) = 8.42; F(2,17) = 8.50]$ and a significant interaction between match and local noun number $[F(1,95) = 12.7; F(2,17) = 5.99]$. Pairwise planned comparisons showed that there were significantly fewer corrects for preambles with singular heads and plural local nouns than for preambles with singular heads and singular local nouns (the controls), 110 vs 131. The corresponding difference for preambles with plural heads and singular local nouns relative to their controls (139 vs 149) was reliable for participants but not for items. The 95% confidence intervals for these comparisons were 9.6 and 15.9 for participants and items, respectively. The regularity of the local noun yielded no significant effects (all the Fs for main effects and interactions involving this factor were less than 1.81).

The table shows that the mismatch local noun was a preamble in which the head noun is the same as the head in the mismatch preamble but the local noun is different in number (e.g. The trap for the rat), the value of the match local noun is always the opposite from the mismatch local noun.
The distribution of the errors was very similar to that for the correct responses. When the two measures are considered together to assess the error rate, and adjusted for the occurrence of errors in the control conditions, the results depicted in Fig. 1 emerge. The figure displays the incidence of agreement errors among all of the number-inflected verbs as the net proportions of agreement errors. The net proportions are the proportions of errors among all of the responses with number-inflected verbs (i.e., both correct and error responses), adjusted for extraneous errors by subtracting the proportions of errors in the control conditions from the proportions of errors in the corresponding mismatch conditions. Figure 1 clearly shows the preponderance of errors after plural local nouns, and the similarity in the patterns for regular and irregular forms. Although there appear to be more errors after singular local nouns from irregular paradigms than after singulars from regular paradigms, a similar but somewhat smaller increase occurred for the plural forms.

Among the ambiguous responses, the only reliable effect occurred for noun number: There were more ambiguous responses after singular heads than after plural heads \([F(1,95) = 5.75; F(1,7) = 6.52]\). For the miscellaneous responses, two results were significant for participants but not for items: There were more miscellaneous responses in the mismatch than in the match condition \([F(1,95) = 5.85; F(1,7) = 4.31]\), but most of these occurred when the local noun was plural \([F(1,95) = 5.35; F(1,7) = 5.09]\).

![Figure 1](image-url)
There were three agreement errors in the miscellaneous responses, two after preambles with singular heads and plural local nouns (one regular and one irregular) and one after a preamble with a plural head and a singular local noun.

Discussion

The main outcome of this experiment was that the regularity of plural marking did not change the tendency for plural local nouns to attract agreement. Regular (boys) and irregular (men) plural local nouns were about equally likely to be followed by correctly agreeing verbs (and about equally likely to be followed by erroneously agreeing verbs), and both were less likely to be associated with correct agreement than were singular local nouns. These trends were stronger when the head and local nouns mismatched in number. The results parallel those previously obtained for regular plurals (Bock & Miller, 1991), and suggest that it is not the regular morphology of the plural that controls agreement, but a more abstract specification of number.

There was no clear support for the conjecture that singular local nouns from irregular paradigms are more likely to create attraction errors than singulars from regular paradigms, as might be expected if the former are cognitively or linguistically atypical (Tiersma, 1982). Even so, the summary of the results in Fig. 1 reveals a very weak trend in the predicted direction. Since the error rate in the present experiment was too low to allow a strong test, it would be appropriate to give the hypothesis further scrutiny.

When the distribution of responses is viewed from the perspective of the number of the head rather than the number of the local noun, a clear tendency can be seen for plural heads to be associated with correct agreement more often than singular heads, regardless of the number of the local noun. This result suggests that agreement with plural-marked heads may be more reliable than agreement with singular heads, in keeping with the assumption that the singular has the status of a default rather than a represented value, and is easily overshadowed by ambient plurality. However, because this result does not accord with several previous findings, it should be treated cautiously. In the experiments reported by Bock and Miller (1991), plural heads were not uniformly superior to singulars. There as here, plural heads with singular local nouns were more often associated with correct agreement than were singular heads with plural local nouns. But when the heads and plural local nouns matched in number, singular and plural heads were about equally likely to be correct.

EXPERIMENT 4

The results of the first three experiments suggested that the number on verbs is controlled by some abstract specification of the number of the subject, rather than by the concrete features of morphological marking. However, the results do not illuminate the nature of that specification, in particular whether it is grounded in number meaning or in a lexical stipulation of singularity or plurality. In Experiment 4, we examined whether local nouns induce errors that reflect their notional number, which may be plural, or their subcategorised number, which is most often singular. We expected that if notional number has an effect on number agreement, we should see plural attraction more often after singular collectives (e.g. army) than after what we will call singular individual nouns (e.g. soldier).

We compared the collective nouns both to semantically related individual nouns and to form- and frequency-matched individual nouns that were largely unrelated to the collectives in meaning. This latter control was included in order to help correct for any contributions of local-noun length or frequency to agreement, which might arise from effects of the frequency of particular noun–verb combinations (Nixon, 1972).

To ensure the accuracy of our assumptions about the notional and subcategorical features of collectives, especially the collectives employed in this experiment, we gathered judgements of their notional number and normative data on their agreement properties. We found that the singular collectives were judged to have plural reference about 40% of the time (vs 10% for singular individual nouns), but still took singular verb agreement about 95% of the time. The details of these validation tests are included in the Results section below.

Method

Participants. Ninety-six Michigan State University undergraduates participated in the experiment in exchange for credit in introductory psychology courses. None of them had participated in the first three experiments, and they were all native speakers of English.

Materials. There were 16 sets of experimental preambles with a singular head noun phrase followed by a prepositional phrase. The prepositional phrases in each preamble set contained local nouns that were either singular or plural. The singular forms included collective nouns that denoted groups of people, animals or objects, and individual nouns that
denoted single people, animals or objects. The plural local nouns were the plural forms of the collective and individual nouns. The collective nouns were selected from a dictionary of collectives (Sparkes, 1985). Because animate collectives may be more likely to be treated as plural than inanimates (Jespersen, 1954), all but one of the collectives denoted groups of people or animals (e.g. audience, herd) or incorporations of them (e.g. village, fleet), which are ambiguous between the animates and inanimates that comprise them. The single dominantly (although not exclusively) inanimate collective was forest.

An example of the preambles in a single set is given in Table 6. Each set included two types of individual nouns. The first was semantically matched to the collective, in that the nouns generally denoted individuals likely to be included in sets denoted by the collective nouns. Some clear cases are the individual nouns corresponding to the collectives army, choir and fleet, which were soldier, singer and ship. The only major deviation from a partonymic relation between the collective and individual nouns was the meaning-mate for the collective jury, which was judge. The second type of individual noun was matched to a singular collective in form and frequency, and had the same number of syllables as the corresponding collective and the same frequency of occurrence according to Francis and Kučera (1982). The median frequency of the collective nouns was 64.5 occurrences per million (with a range of 2–902) and the median frequency of the matched individual nouns was 65 occurrences per million (with a range of 4–832). The median of the frequency differences between the matched words was 1.5, with a range of 0–37.

The head nouns in each preamble set were identical for 14 of the 16 sets. In the other two sets, different heads were used for the semantic- and frequency-matched preambles in order to make them about equally sensible.

In addition to the experimental items, there were 40 filler preambles. Half consisted of a determiner–adjective–noun sequence and half of a determiner–noun sequence. Within each type, 6 were singular and 14 were plural so that, when combined with the experimental items, each participant received an equal number of preambles with singular and plural head nouns.

Eight lists were constructed from these materials. Each list contained all the fillers and 16 experimental preambles, one preamble from each experimental set. Four of the lists contained the preambles with individual nouns that were semantically matched to their corresponding collectives along with those collectives, and the other four contained the individual nouns that were matched in form and frequency to their corresponding collectives along with the collectives. Within each list, there were four experimental preambles representing each of the four forms of local noun. Across all eight lists, each experimental preamble occurred once. The lists were assembled using the audio-recording methods described in the previous experiment, and ordered in the same way.

Procedure. The procedure was the same as in Experiment 3.

Scoring. Application of the scoring criteria described for the earlier experiments yielded 969 correctly agreeing verbs (63.0% of all responses), 158 agreement errors (10.3%), 259 ambiguous verbs (16.9%) and 150 miscellaneous responses (9.8%).

Design. There was one between-subjects factor (semantic vs form- and frequency-matching) and two within-subjects factors (collective vs individual local nouns and singular vs plural local nouns). Half of the participants received the collective local nouns and their semantically matched individual nouns, and the other half received the collectives and their form- and frequency-matched individual nouns. Within each of these two groups, each participant received four preambles representing the orthogonal combinations of the collective/individual and singular/plural local noun factors.

In the design for items, all three factors were crossed. Each item was presented to eight participants in each of the eight cells formed by the orthogonal combinations of the factors collective/individual, singular/plural, and semantic matching/form- and frequency-matching.

Results

The numbers of responses in each condition for each scoring category are shown in Table 7. Figure 2 gives the net proportions of agreement errors for the collective and individual local nouns, pooling the responses for the semantic and form- and frequency-matched conditions.
Table 7 and Fig. 2 show that collective local nouns, like individual local nouns, elicited errors almost exclusively when they were subcategorically plural, and almost never when they were only notionally plural. Overall, 98% of the errors occurred after subcategorical plurals, and of the three errors that occurred after subcategorical singulars, only one occurred after a collective noun. Likewise, there were more correctly agreeing verbs after subcategorically singular than after subcategorically plural local nouns, with no differences attributable to the collective vs individual meanings of the local nouns. The analyses of variance confirmed that there was a reliable effect of the subcategorised number of the local noun [$F(1,94) = 101.5; F_2(1,15) = 29.3\times3$].

There was a trend towards a greater number of correctly agreeing verbs (as well as a smaller number of agreement errors) after plural individual than after plural collective nouns, but this was marginally significant only in the participant analysis, appearing in the main effect of collectivity [$F(1,94) = 2.98, P < 0.09; F_2(1,15) = 2.34, P > 0.10$] and in the interaction between collectivity and subcategorised number [$F(1,94) = 3.09, P < 0.09; F_2(1,15) = 1.73, P > 0.10$].

The types of pairings between the individual and collective nouns had very little impact on the distributions of corrects and errors. None of the interactions involving this factor were significant, and only one main effect approached reliability. The form- and frequency-matched individual and collective nouns elicited slightly more number-inflected verbs (both correctly and incorrectly inflected) than the semantically matched individual and collective nouns, but this tendency was weak [$F(1,94) = 2.71, P = 0.10; F_2(1,15) = 2.38, P > 0.10$].

The ambiguous responses produced no reliable effects. There were more miscellaneous responses from the preambles that included the semantically matched controls than from those that included the frequency controls [$F(1,94) = 9.66; F_2(1,15) = 12.27]$ and more when the local noun was plural than when it was singular [$F(1,94) = 4.94; F_2(1,15) = 4.30$]. No other effects approached significance.

There were 17 agreement errors among those miscellaneous responses that retained singular head nouns. Of these, 15 followed plural local nouns and 2 followed singular local nouns, one of them individual and the other collective (assembly, miscast from the prescribed assemblies). Three other errors occurred when the number of the head noun was changed from singular to plural but the number of the produced verb was singular.

**Validation Tests.** To help to ensure that our assumptions about the semantic and agreement properties of collectives were correct, we examined agreement patterns in verbs that followed singular collective subjects in written and oral sentence completion tasks and obtained judgements of the plurality of singular collectives.

1. **Sentence completions:** Oral and written sentence completions were available for subsets of the 16 collectives employed in Experiment 4. In the first oral completion task, 34 speakers received a recorded list of simple
nouns (e.g. The jury). After hearing each noun phrase, the speakers repeated it and then completed it as a sentence. The list included 12 of the 16 collectives employed in Experiment 4 (assembly, forest, minority and village were missing). Of the 163 number-inflected verbs that were produced with these collectives, 96.1% were singular. For comparison purposes, the list also included 20 mass nouns such as silverware (which rarely inflect for number and are otherwise obligatorily singular). Of the 523 number-inflected verbs produced with these nouns, 98.8% were singular.

In the second oral completion task, 39 speakers produced completions for simple noun phrases that they read aloud from a computer screen and then completed with a sentence containing a predicate adjective. The list contained 15 of the 16 singular collectives from Experiment 4 (forest was missing) and 13 of the 16 semantically matched singular and plural individual nouns. Of the 186 number-inflected verbs produced after the collectives, 97.8% were singular. After the singular individual nouns, all 163 number-inflected verbs were singular; after the plural forms, all 165 were plural.

In the written completion task, 94 participants produced written completions for simple noun phrases presented in a printed list. The list included 14 of the 16 collectives employed in Experiment 4 (assembly and forest were missing), as well as 21 mass nouns (including all 20 from the first oral completion study). Of the 485 number-inflected verbs produced after the collectives, 93.5% were singular, and of the 1236 number-inflected verbs used after the mass nouns, 99.5% were singular. The list also included eight regular plural nouns (e.g. teachers), after which 0.4% of the 427 number-inflected verbs were singular.

2. Judgement task: The plurality judgement task employed all of the collectives and the frequency- and semantically-matched nouns from Experiment 4, in both their singular and plural forms. Two lists were created, with an equal number of items of each type (collective singular, collective plural, individual singular, individual plural) on each list. Within each list, all of the collectives and matched nouns appeared only once (in either the singular or plural form); the alternate form occurred in the other list. The words were randomly ordered, with the constraint that the collectives could not be directly preceded or followed by their semantic pairmates.

The judges were 72 Michigan State University undergraduates, none of whom had participated in the agreement experiments. They were instructed to indicate, for each word, whether it represented “one thing” or “more than one thing”. Specifically, they were asked to answer the question “If you were thinking about the _____, would you be thinking about one thing or more than one thing?”

The responses to this test indicated, not surprisingly, that plurals were judged to represent “more than one thing” much more often than singulars [0.90 vs 0.20, respectively; F1(1,71) = 361.8; F2(1,15) = 2678.2]. However, among the singulars, there was a clear disparity in the ratings for the collective singulars and the regular singulars, with the collectives judged to represent “more than one thing” four times more often than the regular singulars [0.41 vs 0.10, respectively, producing a significant interaction between number and noun type: F1(1,71) = 42.0; F2(1,15) = 36.4]. The collective plurals and regular plurals did not differ (0.90 and 0.89, respectively).

We correlated the multiplicity judgements for the singular collective nouns with the number of correct agreement responses for the corresponding singular items in the preamble completion task. If there is any relationship between the apparent multiplicity of a collective and its tendency to elicit agreement errors, correct (singular) agreement should be less reliable after collectives that are judged to be more multiple in meaning. The obtained correlation for the 16 items was r = −0.48, a value that differs significantly from zero [r(14) = 2.03].

Discussion

The results of the validation tests confirm that English speakers, though they often understand singular collective nouns to carry plural meaning, are strongly disposed to treat them as singular for purposes of verb agreement. In the error elicitation task, when singular collectives served as local nouns, the agreement results were essentially the same as the results for the singular individual nouns. So, even for verbs that disagreed with the subject in number, subcategorically rather than notionally singular number predominated in the selection of verb number. Errors did occur after subcategorically plural local nouns (e.g. soldiers and armies) but not after notionally plural but subcategorically singular local nouns (collectives such as army). These results suggest a primary role for subcategorised number in the control of normal agreement.

However, two other findings from this experiment point towards the possibility of some impact of notionally number on agreement. First, there was a weak trend towards less reliable agreement after plural collective local nouns than after plural individual local nouns. This suggests that the enhanced plurality of plural collectives, combining the collective sense and the normal plural sense, may increase the likelihood of plural marking on the verb. The second finding came from a correlation between agreement performance and the plurality judgements of the local nouns in the validation tests. The tendency of singular collectives to be regarded as
denoting “more than one thing” was related to less reliable use of correct, singular agreement when the same collectives appeared as local nouns.

Despite its suggestiveness, the latter finding is not clearly interpretable. As we noted when describing the materials, there was some variability among the collectives in the extent to which they denoted groups of animates and, in the judgement task, two of the “least animate” were tied for the lowest rank in rated multiplicities (village and forest). They also elicited high numbers of correct responses. Because animacy is associated with the use of regular past-tense verbs for semantic rather than syntactic reasons (Bock & Miller, 1991), and because regular past-tense verbs are not overtly marked for number, greater animacy can decrease the incidence of correctly inflected verbs not because of interference with the agreement process, but because of an increase in the use of number-invariant verb forms. If something of this sort created the negative correlation between judged multiplicity and the use of correctly inflected verbs, there should be a positive correlation between judged multiplicity and the use of ambiguous verbs. In fact, the latter correlation was 0.41 [r(14) = 2.00], which is very similar in magnitude to the correlation for correctly inflected verbs (r = −0.48). This, along with the absence of an effect of collectivity or judged multiplicity on agreement errors, points towards a meaning- or message-based rather than an agreement-based origin for the correlation between judged multiplicity and verb use.

A related feature of the agreement results deserves note. The slight increase in inflected verb forms after form- and frequency-matched individual- and collective nouns may also be attributed to animacy variations. In the form- and frequency-matched conditions, the local noun was more often inanimate than in the semantically matched conditions, and may have given the subject a more inanimate connotation that elicited predications requiring the use of to be, either as an auxiliary or copula.

GENERAL DISCUSSION

These experiments have begun to explore some of the processing underpinnings of number agreement on verbs in English. The first two experiments showed that variations in verb agreement could not be elicited by the phonological correlates of nominal plurality. So, local plurals prompted erroneous verb number marking; local singulars with final consonants matched to those of the plurals did not, even when the local singular was homophonic with the plural (e.g. rose, rows). In Experiment 3, we found that irregular plural marking (e.g. foot-feet) is comparable to regular plural marking (e.g. hand-hands) in its effect on agreement. Finally, in Experiment 4 we found that plural meaning, as represented in such collective nouns as army, was no more likely to attract plural verb number than singular meaning, as represented in such individual nouns as soldier. Since variability in verb number was attributable primarily to the subcategorised plurality of the pre-verbal noun, with little influence from the phonological or semantic correlates of plural number, our conclusion is that the usual fluent control of verb number rests with a lexical specification of plurality that cannot be equated with, and is not even heavily affected by, plural meaning or regular plural marking.

One implication of this is that words that are invariably plural but not inflected for plurality (e.g. people) should be as likely to create attraction errors as inflected plurals. Our attempts to examine this hypothesis have been hindered by the fact that there are only three such words in English that are in common use (people, police and cattle) and preliminary testing has shown that nearly 20% of our speakers exclude cattle from this group, treating it as singular. It is even possible to find the word people used singularly by adults (see Mervis & Johnson, 1991, for examples). Still, the data we have collected on errors following matched preambles such as The problem with the people and The problem with the individuals have revealed reassuringly similar error proportions (0.05 and 0.06 for the invariant and inflected plurals, respectively, with no errors after matched singular local nouns). Because all of the errors for the invariant plural local nouns occurred after people, the generality of the effect for these nouns must remain in doubt, but the trends are nonetheless consistent with the lexical plurality hypothesis.

All of these results mesh well with traditional views of number and grammatical agreement. On those views, verb number carries little meaning in and of itself: The difference between the verb forms sings and sing does not have the same impact as the difference between the noun forms song and songs. Also in line with this view are results which show that children have little or no understanding of the possible meaning of the verb form difference, despite having nearly perfect control of verb form variations in the production of agreement (Keeney & Wolfe, 1972). The results are somewhat less favourable to arguments which emphasise the grounding of verb agreement in the semantics of number (Pollard & Sag, 1988). Though nominal number marking has obvious notional correlates, the control which that marking seems to have over verb number is not necessarily conferred by its meaning.

Putting together the results of these and previous experiments, the central features of attraction errors in English are as follows:

1. Attraction is not a simple consequence of the proximity of the local noun to the verb, because singular local nouns have very weak (albeit non-negligible) effects on verb number (Bock & Miller, 1991).
2. Agreement is implemented between the head noun and verb within individual clauses, and so conflicting number information from outside a clause is less likely to cause attraction errors than conflicting number information within the clause (Bock & Cutting, 1992).

3. Local noun endings with the phonological properties of the regular plural are not sufficient to create attraction, as they should be if possession of the phonological properties of plural subject arguments were responsible for attraction.

4. Variations in the animacy of local nouns do not create variations in attraction, as they should if possession of the semantic properties of subject arguments were responsible for attraction (Bock & Miller, 1991).

5. The notional number of the local noun (or of the entire preamble; Bock & Miller, 1991) has little effect on the occurrence of attraction.

6. The most powerful factor in attraction is the subcategorised plurality of local nouns. So, local nouns that are plural, both regularly and irregularly plural, are associated with the production of plural verb forms, even when the number of the head noun is singular.

Proceeding on the assumption that the factors central to the occurrence of attraction errors are central to the normal implementation of agreement, we can begin to outline how simple grammatical agreement works in language production. To do this, we will adopt and amend the model of verb-form retrieval offered by Lapointe and Dell (1989). In the model, a specification of features associated with the clause (including the number of the subject) is employed in looking up the properly inflected verb form. To explain the restriction of attraction to subcategorised number, the specification of number features must be dominated by the characteristics of the lexical items designated to serve the subject function (e.g. whether they are mass or count, and if count, whether they are to be marked as plurals). The error results suggest that the singular is unspecified for nouns, and therefore singular verbs will be retrieved by default unless the head is marked as plural.

One limitation on any general account of agreement errors stems from the disproportionate use of irregular verb forms in errors. The wide majority of the number-marked forms in the present experiments were forms of to be, raising the possibility that errors are not the product of regular inflectional processes, but of erroneous retrieval of the stored forms of irregular verbs. However, examination of the proportions of errors involving irregular and regular forms undermines this suggestion. Across all of our experiments, there were 2499 uses of forms of to be, 226 of them in error (9%), against 52 uses of regular verbs, with 10 errors (19%). In previous work (Bock & Miller, 1991), the tendency was slightly in the opposite direction (there were errors on 8% of irregular forms vs 5% of regulars). Because regular forms are so few in number that small changes in error frequency create large percentage changes, we cannot estimate with confidence the error rate among regular verbs. However, the rate appears to be not so different from that for irregular forms that a different explanation is likely to be required. We believe that it is erroneous number marking on the verb that precipitates agreement errors, and that the regularity of the verb form itself is probably inconsequential.

Verb regularity may nonetheless have a discernible impact on a different type of error. Stemberger (1984) showed that the probability of erroneously dropping the third-person-present singular inflection from a regular verb form is nearly eight times higher than the probability of adding it (so speakers are more likely to say build when they intend builds than the other way around). This does not seem to be attributable to a general tendency to change singular-agreeing forms to plural-agreeing forms, because among irregularly inflected to be forms, the trend was reversed: Speakers were more likely to say was when they meant were (and is when they meant are) than the other way around. These errors may be due in part to the substitution of higher- for lower-frequency forms, arising during the assembly or retrieval of the verb form itself, and may be distinguishable from errors that arise within the agreement process (Stemberger, 1985b). In our studies, form errors should be distributed equally over the experimental and control conditions.

From the broad perspective of the study of language processing, the results of the present experiments are consistent with a view of sentence production in which certain components of the process are somewhat insulated from those aspects of cognition that directly inform our interpretations of experience. Some of the components that are insulated in this way seem to be heavily invested in the creation of syntactic structures (e.g. Bock & Loebell, 1990; Goldman Eisleer, 1968). Since agreement is bound into this structural system, it makes sense for it to be triggered by information that may be relevant only within this system. The normal use of language puts a premium on efficient processing, and it may not be especially efficient to have to defer to number meaning in the implementation of number marking, given the vagaries of the former. Instead, by accessing and using a digitisation of the dimension of number that is encoded within the lexicon, the formulator may successfully convey most of the important variations in number without having direct access to their cognitive correlates.
Limits on the Hegemony of Lexical Number

Although subcategorisations of number may adequately explain most instances of agreement in everyday English use (at least in dialects widely spoken in North America), there are clear and notable exceptions. Consider the sentence “The number who know is four” (referring to the members of the Bush administration with advance knowledge of the date for the beginning of the ground offensive in the Gulf War; quoted in Kondracke, 1991, p. 9). In it, the matrix verb is, under the control of the subject the number, is singular. However, the verb of the embedded clause (know) is plural, presumably agreeing with the number of the relative pronoun who, which must in turn be determined by its antecedent. That antecedent is, apparently, not the number. Instead, who seems to refer to the individuals who know rather than to their cardinality. Evidently, verb number can be determined by information that may reflect notional number more or less directly, implying that the mechanisms of agreement are not entirely insulated from non-linguistic information sources.

Lexical specifications of number may nonetheless be used in preference to notional specifications not only because of the difficulty of specifying notional number, but also, on some occasions, its irrelevance. Even when speakers are indifferent to the wholistic vs distributive interpretation of collective subjects, the grammar requires that verbs agree with those subjects in number. In the circumstances, the lexicon offers a solution in the form of a stipulation about the number of the noun. The relative arbitrariness of that stipulation may account for the differences between British and American English in their treatment of collectives, and we are investigating that possibility in ongoing research. Related to this issue is the question of whether and how notional number control operates in situations where speakers (or hearers) are not indifferent to the wholistic vs distributive interpretation.

Although lexical control of agreement dominated our findings, this dominance might disguise interactions of or conflicts between notional and lexical number that are reliably resolved in favour of lexical number. We have begun to examine this in experiments using a chronometric measure of the production of verbs after simple sentence subjects. So far, we have obtained no evidence that the conflict between notional and lexical number that is inherent in singular collectives affects the implementation of number agreement.

Because of the emphasis within connectionist theorising on the interactivity of information in language processing (McClelland, 1987), it would be of some interest to see how such models could reproduce the various findings we have obtained. Opening the way for this, Elman (1989) created a distributed connectionist model of structural processing that uses subject–verb agreement performance as one of its tests. However, the fit between the model and the present findings cannot be readily evaluated for two reasons. First, the test of the model was its overall ability to predict correct agreement, and the sources of variability in its performance and the kinds of errors that it produced were not reported. Secondly, the model included only morphological and structural information, and was but was still able to produce only syntactically grounded agreement.

It may nonetheless be possible for future versions of the model or for others like it to account for important features of the production of agreement. There are reasons to believe that connectionist models place natural limitations on interactivity (Dell & O'Seaghdha, 1992) and readily accommodate a modular organisation of information (Tanenhaus, Dell, & Carlson, 1987). Our results suggest that this may be essential to the explanation of agreement performance, in that there are notable restraints on the ways in which the language processor (or formulator, to tie the case specifically to production) uses the many different kinds of number information that are in principle available to mature language users.

In immature language users, issues of English verb-number agreement have received relatively little attention. Perhaps this is a consequence of a fast and trouble-free developmental progression: The rudiments of number knowledge are available to infants and children (Gelman & Gallistel, 1978; Starkey, Spelke, & Gelman, 1990), the inflections involved in agreement make relatively early appearances (Brown, 1973; Cadzen, 1968; deVilliers & deVilliers, 1973), and they are reliably produced in the spontaneous speech of 3- to 5-year-olds (Keeney & Wolfe, 1972). Missing from the literature is information about any factors that might be associated with variations in the use of number agreement before and after it comes to be implemented reliably, including the notional features that might affect it. In the only study we know of that has examined this, Stromswold (1983) carried out elicited production studies with children between the ages of about 4 to nearly 5½. She manipulated whether the verb was more actional (i.e. a prototypical verb such as push) or more spatial (e.g. cover), reasoning that if children’s form class categories are semantically based, there should be variations in agreement performance such that more typical verbs are associated with more reliable agreement. Performance on the two types of verbs was equivalent, suggesting that by the time verb agreement is in place in a child’s language, it is grammatical form class rather than semantic privilege that governs its use, at least wi

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3Bloom, Lifter and Hafitz (1980) examined the development of the third-person singular, progressive and past-tense inflections, but focused on their contrasting semantic properties within the tense/aspect system, rather than their agreement properties.
respect to the verb itself. What may go on earlier, and what may go on with respect to notional vs lexical number properties, remains to be explored.

CONCLUSION

The evidence from attraction errors indicates that, in normal language production, the traditional description of number agreement between verbs and their subjects may be largely correct. What controls the form of the agreeing verb is not number meaning or plural morphology, but the subcategorised number of the head of the subject noun phrase.

From some standpoints this is an unremarkable finding. After all, the canonical features of verb agreement in English can be readily described only in terms of a construct such as lexical or, in traditional terms, grammatical number. However, idealised features of agreement could be rather loosely related to what happens in spontaneous speech, and even more loosely related to what controls verb number in attraction errors. This was clearly the view of Quirk et al. (1985), who suggested that in ordinary circumstances, notional number prevails: “People often experience a conflict between grammatical concord and . . . notional concord, which tends to prevail over it” (p. 757). The surprise, then, is the degree to which subcategorisation number seems to control verb marking even at the edges of the agreement system. We have therefore argued that the implementation of agreement is directly affected by an abstract marking of number that is not equivalent to notional number or to overt number inflection. This favours the idea that beyond an initial mapping from the to-be-expressed message, syntactic production processes may commonly ignore relevant sources of information. One of the many challenges that remain is to explain how this blinking is overcome on those occasions when agreement appears to be notionally controlled.

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REFERENCES


APPENDIX

Experimental preambles from Experiment 1 (local nouns are listed in the order singular/pseudoplural/singular/true plural):

1. The player on the course/court/courts
2. The apartment with the lease/leak/leaks
3. The student with the pass/pack/packs
4. The horn on the bus/buck/bucks
5. The noise from the class/clap/claps
6. The reward for the maze/maid/maids
7. The need for the gauze/god/gods
8. The purpose of the kiss/kit/kits
9. The man with the case/cape/capes
10. The reason for the force/fort/forts
11. The wheel with the brace/brake/brakes
12. The condition for the race/rate/rates
13. The size of the nose/node/nodes
14. The smell of the sauce/sock/socks
15. The explosion from the fuse/fame/fames
16. The scale for the mass/map/maps
17. The sound of the hiss/bit/bits
18. The ruling about the loss/lot/lots
19. The argument over the place/plate/plates
20. The result of the toss/talk/talks
21. The type of trace/trait/tracks
22. The garden with the spice/spike/spikes
23. The beauty of the lace/lake/lakes
24. The problem with the gas/gap/gaps
25. The struggle over the rice/right/rights
26. The boxer with the great face/fake/fakes
27. The map with the crease/creek/creeks
28. The story behind the miss/myth/myths
29. The compliment on the grape/grapes
30. The lake with the bass/bat/bats

Experimental preambles from Experiment 2 (local nouns are listed in the order singular pseudoplural/true plural/singular):
1. The reason for the big size/sigh/sigh
2. The explanation of the cause/caws/caw
3. The type of tax/tacks/tack
4. The peculiarity of the pause/paws/paw
5. The purpose of the wax/whacks/whack
6. The appearance of the rose/rows/row
7. The alcohol for the bruise/brews/brew
8. The gardener with the hose/hoes/hoe
9. The beginning of the phrase/frays/fray
10. The ship for the cruise/crews/crew
11. The removal of the clause/claws/claw
12. The damage from the raise/rays/ray

Experimental preambles from Experiment 3 (local nouns are listed in the order singular irregular/plural irregular/singular regular/plural regular):
1. The trap(s) for the mouse/mice/rat/rats
2. The operation(s) on the foot/feet/hand/hands
3. The cracker(s) for the goose/geese/swan/swans
4. The game(s) for the child/children/kid/kids
5. The job(s) for the man/men/boy/boys
6. The interview(s) for the woman/women/lady/ladies
7. The prize@ for the ox/oxen/horse/horses
8. The X-ray(s) for the tooth/teeth/mouth/mouths

Experimental preambles from Experiment 4 (local nouns are listed in the order singular collective/plural collective/singular semantically matched individual/plural semantically matched individual/singular form- and frequency-matched individual/plural form- and frequency-matched individual. Head nouns, where they differed, are listed in order according to whether they were employed with the semantically matched or the form- and frequency-matched local nouns):
1. The strength of the army/armies/soldier/soldiers/machine/machines
2. The sight of the village/villages/house/houses/murder/murders
3. The time for the assembly/assemblies/student/students/instruction/instructions
4. The purpose of the gang/gangs/delinquent/delinquents/joke/jokes
5. The jealousy/size of the clan/clans/relative/relatives/dove/doves
6. The location of the forest/forests/tree/trees/bottle/bottles
7. The job for the choir/choirs/singer/singers/convict/convicts
8. The support from the posse/posses/deputy/deputies/patron/patrons
9. The need for the committee/committees/member/members/decision/decisions
10. The function of the jury/juries/judge/judges/engine/engines
11. The view of the audience/audiences/spectator/spectators/hospital/hospitals
12. The disappearance of the minority/minorities/politician/politicians/delivery/deliveries
13. The record/color of the team/teams/player/players/sea/seas
14. The type of group/groups/individual/individuals/word/words
15. The noise from the herd/herds/cow/cows/hog/hogs
16. The condition of the fleet/fleets/ship/ships/pan/pans