Brain and Language **81,** 342–357 (2002)
doi:10.1006/brln.2001.2529, available online at http://www.idealibrary.com on IDEAL®

The Selection of Grammatical Features in Word Production: The Case of Plural Nouns in German

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Published online January 22, 2002

Two experiments investigate the effect of number congruency using picture–word interference. Native German participants were required to name pictures of single objects (*Nase* 'nose') or two instances of the same object (*Nasen* 'noses') while ignoring simultaneously presented distractor words. Distractor words either had the same number or were different in number. In addition, the type of plural formation (same or different inflectional plural suffix) and the semantic relationship (same or different semantic category) between target and distractor were varied in Experiments 1 and 2. Results showed no effect of number congruency in either experiment. Furthermore, the type of inflectional suffix did not exert an influence on naming latencies in Experiment 1, but semantic relationship led to a significant interference effect in Experiment 2. The results indicate that selection of the number feature diacritic in noun production is not a competitive process. The implications of the results for models of lexical access are discussed. © 2002 Elsevier Science (USA)

Agreement is an important aspect of many languages. In the course of language production, grammatical features such as number and gender are used to control agreement. Whereas gender is an intrinsic feature of nouns (Corbett, 1991), number is a grammatical feature that has to be specified for nouns based on conceptual information. Number is used to control NP agreement and subject/verb agreement. Bock and her colleagues (Bock & Miller, 1991; Bock & Eberhard, 1993; Bock, Nicol, & Cooper Cutting, 1999) investigated the circumstances under which native speakers failed to produce number agreement. They found that semantic and morphophonological factors of the subject of the sentence are of minimal relevance to the syntactic and morphological processes that implement agreement. Instead, agreement control of verb number is achieved by lexical specification of plurality on the subject noun.

The lexical specification of plurality on nouns is made by means of grammatical features. But how are grammatical features selected in the process of language production? One hypothesis holds that the selection of grammatical features is a competitive process. For instance, Schriefers (1993; see also La Heij, Mak, Sander, & Willeboordse, 1998; Schiller & Caramazza, submitted a; Schriefers & Teruel, 2000; Van Berkum, 1997) reported a *gender congruency effect* in Dutch. Using the picture–

The research reported here was supported in part by National Institutes of Health Grant DC04542. Niels O. Schiller is now supported by the Dutch Royal Academy for Arts and Sciences. The authors thank an anonymous reviewer for his or her comments.

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0093-934X/02 $35.00

word naming task, he obtained faster reaction times when picture target and distractor word had the same gender than when they had different gender. Schriefers (1993) interpreted this effect as reflecting competition in the selection of a word's syntactic features. He argued that the activation of the gender feature of the distractor word interferes with the naming of the picture in those cases where the distractor's gender is different from that of the target noun. This is because two different gender specifications compete for selection in the gender-incongruent condition, whereas this would not be the case in the gender-congruent condition.

However, there are several results that are problematic for Schriefers's (1993) feature competition account. First, Caramazza and colleagues could not replicate the gender congruency effect in Romance languages (Alario & Caramazza, 2002; Costa, Sebastián-Gallés, Miozzo, & Caramazza, 1999; Miozzo & Caramazza, 1999). Miozzo and Caramazza (1999) proposed two possibilities for why they failed to replicate Schriefers's (1993) results in Italian. One possibility is that competition in gender feature selection occurs in all gender-marking languages but that specific properties of individual languages may render the effect ''invisible.'' In Dutch, the determiner form in an NP can be selected on the basis of the noun's gender alone, whereas in Romance languages such as Italian it cannot. For example, the Italian singular masculine definite article can be either *il* or *lo* depending on the phonology of the word that follows it: *il tavolo* ('the table') but *lo strano tavolo* ('the strange table') and *lo scienziato* ('the scientist') but *il grande scienziato* ('the great scientist'). In these examples, it is clear that the form of the determiner does not depend only on the gender of the noun, or only on the gender of the noun and its phonology, but rather on the gender of the noun plus local phonological context. This means that determiner selection must be a relatively late process; it can take place only after the phonological form of the word that follows it has been specified. A consequence of this characteristic of Italian is that even if the gender feature of the distractor were to interfere with the selection of the target noun's gender feature, such an effect would have been resolved before determiner selection takes place.

Another possibility suggested by Caramazza and colleagues (Caramazza, Miozzo, Costa, Schiller, & Alario, 2001) is that the putative gender congruency effect observed in Dutch is really a *determiner congruency effect* that is only found in languages where determiner selection can occur very early in the NP production process—as is the case in Dutch. That is, if we assumed that determiner form selection is a competitive process, then we might expect slower determiner selection when target and distractor nouns have different genders. This is because in Dutch the selection of the appropriate determiner can be made as soon as the gender information of a noun becomes available, and therefore the activation of a competing determiner (through the activation of the gender of the distractor noun) would interfere with the selection of the target determiner. In Italian, however, determiner form selection occurs so late in the process of NP production that the activation of competing gender information and its associated determiners would long have dissipated, rendering ineffective any competing activation.

The second piece of evidence that is problematic for Schriefers's (1993) feature competition account but consistent with the determiner selection competition account (Miozzo & Caramazza, 1999) is the case of bare noun production. La Heij, Mak, Sander, and Willeboordse (1998) replicated Schriefers's (1993) gender congruency effect in Dutch determiner + noun naming, demonstrating the robustness of the effect—at least in Dutch. However, the effect was absent in bare noun naming, that is, when the picture was named without the determiner. This latter effect has also been obtained with Italian speakers (M. Miozzo & A. Caramazza, unpublished data). If Schriefers's (1993) competitive selection account were correct, then competition

TABLE 1
Examples of Different Plural Formations in German Nouns

Plural Morpheme	Example Singular		Plural	
-n	Hemd	'shirt'	–Hemden	'shirts'
-e	Netz	'net'	– Netze	'nets'
-er	Rind	'cow'	–Rinder	'cows'
-s	Auto	'car'	–Autos	'cars'
-Ø	Fenster	'window'	–Fenster	'windows'
-e + umlaut	Wand	'wall'	–Wände	'walls'
-er + umlaut	Buch	'book'	–Bücher	'books'
-Ø + umlaut	Faden	'thread'	–Fäden	'threads'

between the gender features should also slow down the naming process in the bare noun naming condition. It has been argued, however, that the latter result is not problematic for the competitive feature selection account because features are only selected when they are needed for production (Levelt, Roelofs, & Meyer, 1999). In bare noun naming, no determiner has to be produced, and therefore the selection of the gender feature is not necessary.

A test case of this claim is provided by the production of singular and plural bare nouns, which require that the number feature diacritic be specified for the correct specification of the morphophonological form of a word. Although both gender and number features are treated as diacritic parameters in Levelt's model (Levelt, 1989; Bock & Levelt, 1994; Levelt et al., 1999), they are different in some respects. Whereas gender refers to an intrinsic property of a lexical item (e.g., ''Is an object classified as feminine, masculine, or neuter?''), number is an extrinsic feature, which derives from the conceptual level (e.g., ''Are there one or more entities of an object?''). However, despite this apparent difference between gender and number, both are represented as grammatical features or diacritic parameters in Levelt's model. It is obligatory for all diacritic parameters to be specified before phonological encoding can proceed further. Therefore, if feature selection is a competitive process, then we should observe interference from a distractor word that mismatches in number with a target. The experiments reported below investigate whether a number congruency effect can be found in German.

German Plural Morphology

The experiments were carried out in German because of its relatively rich plural morphology for nouns. German nouns can form the plural with several different plural allomorphs such as -n, -e, -er, -s, and a zero morpheme (Ø). Furthermore, the stem morpheme can alter when forming the plural in -e, -er, or Ø (see Table 1 for examples). This phenomenon is called ''umlaut'' and is triggered by an independent phonological rule of fronting the stem vowel (Wiese, 1987, 1996). Therefore, umlaut is not treated as an independent plural marker.[1] Although the phonological form of a word does not provide strong cues about its plural formation, the correlation between the gender and the morphophonology of the stem and the plural form can be quite high (e.g., masculine and neuter nouns with a final syllable containing a schwa usually form the plural with Ø, polysyllabic feminine nouns form the plural in -n, feminine

[1] Examples such as *Hund* 'dog'–*Hunde* 'dogs'–*Hündchen* 'doggy' show that umlaut can occur independently of the plural formation of a lexical item.

TABLE 2
Distribution of Different Plural Formations in Monomorphemic German Nouns

Plural	Percentage types	Percentage tokens
-n	42.28	40.27
-e	28.50	38.21
-er	2.51	9.62
-s	9.55	3.14
-Ø	16.00	8.76
Rest	1.16	0.60

Note. Plurals in -n and -er include those words that form the plural only with umlaut, that is, without adding a plural suffix as, for example, *Faden* 'thread'–*Fäden* 'threads' and *Bruder* 'brother'–*Brüder* 'brothers'. These cases would have to be added to the Ø-morpheme category. The ''rest'' category includes some foreign words that form the plural in -a (e.g., *Lexicon* 'dictionary'–*Lexica* dictionaries') or -i (e.g., *Konto* 'account'–*Konti* 'accounts') and some words that form the plural with umlaut but do not end in -n or -er as, for example, *Mantel* 'coat'–*Mäntel* 'coats'.

nouns never form the plural in -er). However, there are also many exceptions, for example, *Muskel* (mas, /mvskəl/ 'muscle')–*Muskeln* ('muscles').

It has been claimed that none of the five German plural suffixes is statistically predominant (Köpcke, 1988; MacWhinney & Leinbach, 1991; Marcus, Brinkmann, Clahsen, Wiese, & Pinker, 1995). However, lexico-statistical analyses using the CELEX lexical database for German show that not all of the plurals occur with the same frequency. According to CELEX, there are 30,714 German nouns, of which 3,523 are monomorphemic.[2] Of this set, 3,193 can form a plural. The distribution of the plural forms of monomorphemic German nouns is shown in Table 2. As can be seen, plurals in -n and -e make up about 70% of all occurring plurals type-wise and about 80% token-wise. Interestingly, the -s suffix, which is claimed to be used as the default plural in German (Clahsen, Rothweiler, Woest, & Marcus, 1992; Marcus et al., 1995), is the one that occurs very infrequently in German.

THE EXPERIMENTS

In this study, we used the picture–word interference task. In this paradigm, participants are instructed to name a picture while ignoring a simultaneously presented distractor word. This task is a variant of the Stroop (1935) paradigm and has been used successfully to investigate various aspects of lexical access in language production. Several researchers have shown that picture-naming latencies are affected by specific properties of the to-be-ignored word (e.g., Caramazza & Costa, 2000; Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Lupker, 1979, 1982; Meyer & Schriefers, 1991; Posnansky & Rayner, 1977; Rosinski, Golinkoff, & Kukish, 1975; Schriefers, 1993; Schriefers, Meyer, & Levelt, 1990; for reviews, see Glaser, 1992, and MacLeod, 1991). In the experiments reported below, target pictures had to be

[2] Morphologically complex lexical entries (derivations or compounds) are not considered here because their plurals are completely predictable. Derived nouns form the plural on the basis of their derivational suffixes, and compounds form the plural in the same way as their lexical heads, which is the right-hand constituent of a compound in German.

named in the singular or in the plural. Each of these two conditions was combined with distractor words that had the same or a different number to test whether there was a number congruency effect. In addition, the type of plural formation of target and distractor (Experiment 1) and the semantic relationship between target and distractor (Experiment 2) were manipulated.

Experiment 1: Noun Naming with Number-Congruent and -Incongruent Distractor Words

In this experiment, the effect of number congruency between picture targets and written distractor words was tested. Participants named pictures with singular or plural nouns depending on whether the corresponding objects were presented once or twice. Distractor words appeared superimposed on the target pictures either in the singular (e.g., *Kerze*) or in the plural (e.g., *Kerzen*). Current accounts of lexical access assume that diacritic parameters for grammatical number have to be set at the level of lexical node selection (e.g., Bock & Levelt, 1994; Caramazza, 1997). If target and distractor require different feature specifications with respect to number, then this could lead to interference due to competition between the diacritic features ''singular'' and ''plural'' in the speech production system. This competition may have the effect that the production of the correct form of the target is slowed down relative to the condition in which both target and distractor require the same number feature. If there is a number congruency effect in German, then naming latencies should be faster in the number-congruent pairings than in the number-incongruent pairings.

In addition, the effect of plural formation congruency was tested. Targets formed the plural with either -e or -n, and distractors formed the plural either in the same way as the target or with a different allomorph. If plural suffixes are stored as separate morphemes in the lexicon, then we should observe faster naming latencies when target and distractor have the same plural suffix (due to form priming) as compared to when different suffix nodes are activated.

Method

Participants. A total of 19 participants took part in Experiment 1 in exchange for pay. They were undergraduates from Harvard University or from Marburg University in Germany. All participants were native speakers of German and had normal or corrected-to-normal vision.

Procedure. Participants were tested individually. They sat in front of a computer screen in a quiet, dimly lit room. The experimenter sat in the same room to score errors. On each trial, participants first saw an asterisk for 500 ms in the center of the screen. They were instructed to fixate the asterisk. Then there was a blank screen for 200 ms before the target picture appeared centered on the screen with a distractor word superimposed on it. Participants were required to name the target picture as fast and as accurately as possible while ignoring the distractor word. Naming latencies were measured by means of a voice key (connected to a Radio Shack 33-3005 microphone), which was activated at the onset of target presentation. Target and distractor remained on the screen until a voice response was given, and 500 ms later the next trial started automatically. If no response was recorded within 2000 ms, then target and distractor disappeared from the screen and, after a pause of 500 ms, the next trial started. The trial sequences of the experiment were controlled by PsychLab (Version 1.0–103.1) (Gum & Bub, 1988). A response was considered an error when it exceeded the response deadline of 2000 ms, when it included a speech error, when a wrong name was produced, or when the voice key was triggered incorrectly. Responses that included an error were excluded from the reaction time (RT) analyses.

Design. Participants received one familiarization, two practice, and five test blocks. In a familiarization block, each picture appeared without the distractor words on the computer monitor, and after 2 s the appropriate name was added below the picture. They remained in view together for another 3 s. Participants were asked to use the name provided below each picture. After this familiarization phase, there was a short break followed by two practice and five test blocks. In a practice block, each target (without a distractor word) was presented once as a single object and once as two identical objects adjacent to each other preceded by a fixation point. Participants were asked to name the pictures as soon as they appeared on the screen either

in the singular (single presentation) or in the plural (double presentation). In the rare event that they did not produce the designated name for a given picture, they were corrected by the experimenter. During the five test blocks, each target appeared eight times altogether: four times a single object and four times as two adjacent objects. Distractor words were either number congruent or number incongruent. In addition, each distractor word could form the plural either in the same way as the target or with a different allomorph. That is, the two factors were completely crossed, yielding a 2 × 2 design. All target–distractor pairs were randomized and then split up into five blocks. Each block was randomized individually for each participant, and the order of blocks was varied. There was a short break between each block. The entire experiment took between 50 and 60 min per participant.

Materials. Altogether, there were 50 black-on-white line drawings of common objects that were used as test pictures (see Appendix A). In addition, there were four practice pictures. The target pictures were selected from the picture database of the Max Planck Institute for Psycholinguistics in Nijmegen, The Netherlands. All selected picture names corresponded to monomorphemic German nouns. The nouns were either monosyllabic or bisyllabic with lexical stress on the initial syllable. The mean frequency of occurrence per 1 million word forms (MANNHEIM corpus) was 32.9 for the targets as determined by CELEX (Burnage, 1990; Baayen, Piepenbrock, & Gulikers, 1995). A total of 17 test targets formed the plural with -e, and 33 did so with -n. In addition, 8 test targets had neuter gender, 11 were masculine, and 31 were feminine. Except for 1 item (*Bett* 'bed'), none of the targets occurred as a distractor word. Distractor words were chosen such that they bore no phonological or semantic relationship with the targets. Distractor words were either monosyllabic or bisyllabic with stress on the first syllable. For each target (e.g., Bein 'leg'–*Beine* 'legs'), there were two distractors: one forming the plural in the same way as the target (e.g., *Rohr* 'tube'–*Rohre* 'tubes') and the other one forming it differently from the target (e.g., *Rad* 'wheel'–*Räder* 'wheels'). The mean frequency of occurrence per 1 million word forms was 25.8 for the distractors forming the plural in the same way as the targets and 33.2 for the distractors with different plural formations from the targets. The two distractors for a particular target always agreed in gender with the target and had at least the initial grapheme in common. The mean length in letters was 4.5 for the distractors forming the plural in the same way as the target and 4.3 for the distractors with different plural allomorphs.

Results

Results were straightforward: The main effect of Number of Target was significant by subjects, $F_1(1, 18) = 73.57$, $MSE = 987.05$, $p < .01$, but not by items, $F_2(1, 47) < 1$ (plurals were responded to faster [746 ms] than were singulars [767 ms]).[3] The variable Number of Distractor did not affect naming latencies, $F_1(1, 18) = 1.91$, $MSE = 382.52$, *ns*; $F_2(1, 47) < 1$: Participants were just as fast in naming the target when the distractor was in the singular (756 ms) as when it was in the plural (757 ms). The interaction between Number of Target and Number of Distractor was not significant either: There was no effect of Number Congruency, $F_1(1, 18) = 2.20$, $MSE = 1117.70$, *ns;* $F_2(1, 47) < 1$. In the number-congruent condition, targets were named just as fast (756 ms) as in the number-incongruent condition (757 ms). Neither was there a main effect of Plural Formation Congruency, $F_1(1, 18) < 1$; $F_2(1, 47) < 1$. When distractor and target formed the plural in the same way, targets were named just as fast (757 ms) as when they had different plural formations (756 ms). None of the other interactions was significant.

Discussion

In Experiment 1, participants were just as fast to name a picture paired with a number-incongruent distractor word as to name one with a number-congruent distractor word. The results of this experiment suggest that the selection of the diacritic parameter *number* is not a competitive process because there is no interference effect

[3] However, the comparison of the two practice blocks (plain picture naming) showed a significant 36-ms advantage for singular targets (722 ms) over plural targets (758 ms), $t_1(17) = 2.77$, $SD = 58.37$, $p < .05$; $t_2(49) = 8.37$, $SD = 31.26$, $p < .01$ (from 1 participant, no practice data were available). This effect may be due either to the more complex visual image in the plural condition (two pictures instead of one) or to the additional conceptual, semantic, or morphophonological processing in the plural condition.

when target and distractor differ in number. However, this conclusion may be premature for the following reasons. First, we do not know the extent to which participants processed the distractor words. Participants were 15 ms faster when they were required to name the target picgtures without the distractor words in the practice blocks (741 ms) than they were in the test blocks with distractor words (756 ms). This indicates that there was some interference due to the presence of the distractor words. However, we cannot be sure that participants really processed them *linguistically*. The interference in the test blocks may have been due to the higher visual complexity of the target pictures when presented with the distractor words superimposed. Therefore, we designed a second experiment in which we manipulated not only the number between target and distractor but also their semantic relationship. If we are able to obtain a semantic interference effect using the same task, then we can be sure that participants in our experiment processed the distractor words up to the lexical level.

A second possibility is that participants did process the distractor words but not completely, and because plural is marked at the end of words in German, the difference in number between target and distractor word may have gone unnoticed. There are, however, words in German that include a stem alternation in the plural (so-called umlaut). Although the stem alternation is triggered by the phonological form of a word and has, strictly speaking, nothing to do with plural formation, the umlaut can be used as an indicator for plural. Because umlaut involves the change of the stem vowel of a word, this type of marking may be more salient than the marking by the inflectional suffix alone. Therefore, by analyzing those plurals that included an umlaut, we can check whether or not this second possibility holds. However, the mean RTs show that umlaut plurals did not behave differently from the other distractors in the experiment. Altogether, there were 26 umlaut plurals, and participants took about just as long to name those targets when their number matched with the distractor word (764 ms) than when they did not match (763 ms).

Finally, it should be noted that we found no evidence of a form priming effect in the first experiment. Half of the distractor words formed the plural with the same inflectional suffix as the target (e.g., *Kerzen–Lügen*, *Tische–Orte*). However, there was no effect of Plural Formation. But a ''late'' effect of suffix form overlap may have been expected if the same logic is applied to the case of number as we applied to gender in an earlier study (Schiller & Caramazza, submitted a). In that study, we found effects of gender incongruency only when those were accompanied by differences in form (of the corresponding determiner). However, here we found neither a number feature effect nor a late surface form effect. Why is that so? There may be a couple of reasons for the absence of a suffix form effect. First, the form overlap occurred at the ends of words, whereas the voice key is triggered by the word-initial part of the response, and by the time the surface priming effect from the suffix reached its maximum, the voice key may have already been triggered by the initial part of the response. Second, the shared suffix may have been simply too small to be detected with this paradigm. The overlap consists of one segment only, compared to a whole morpheme in the case of gender/determiner congruency (Schiller & Caramazza, submitted b). Third, it could be that form-priming effects are found only for free-standing morphemes. And last but not least, no effect of suffix priming may be expected to start with if German noun plurals are irregular (except for -s plurals), as argued by Marcus et al. (1995), because irregular plurals may be stored as separate word forms.

Experiment 2: Noun Naming with Semantically Related, Number-Congruent and -Incongruent Distractors

As already noted, the lack of any effect in Experiment 1 could be either because number congruency does not have the same effect as gender congruency or because

participants failed to process the number feature of the distractor word. Although the latter possibility seems unlikely given the difference between the naming latencies in the practice and test blocks, it cannot be excluded irrefutably. In Experiment 2, we added another factor, namely Semantic Relatedness, to check whether or not our participants process the distractor words. In the picture word-naming task, picture-naming latencies are slower when target picture and distractor word are members of the same semantic category. This effect is known as the *semantic interference effect* (Golinkoff & Rosinski, 1976; Lupker, 1979) and has been replicated many times (Caramazza & Costa, 2000; Glaser & Düngelhoff, 1984; La Heij, Starreveld, & Steehouwer, 1993; Levelt et al., 1991; Schiller & Caramazza, 1999; Starreveld & La Heij, 1995, 1996). If we find a semantic interference effect in Experiment 2, then we would know that distractor words are processed lexically.

Method

Participants. A total of 18 participants took part in Experiment 2 in exchange for pay. Most of them were graduate students enrolled in some exchange program with one of the universities in the Boston area. All participants were native speakers of German and had normal or corrected-to-normal vision.

Procedure. The procedure was similar to the one in Experiment 1 except that the asterisk was substituted by the number 1 or 2 to indicate whether the picture had to be produced in the singular or in the plural, respectively.

Design. Participants received one familiarization, one practice, and four test blocks. After the familiarization block, which was similar to the one in Experiment 1, participants received one practice block to practice the production of the pictures in the singular and in the plural. In a practice block, each target picture appeared two times: once preceded by the number 1 and once preceded by the number 2 in the center of the screen. Depending on which number preceded a picture, participants had to produce the singular (1) or the plural (2) of the picture's name as fast as possible. This had the advantage that a single object could be presented in the singular and plural conditions. In the four test blocks, each target appeared eight times: four times in the singular condition and four times in the plural condition. Distractor words were either in the same number as the target (number-congruent condition) or in the other number (number-incongruent condition). Crossed with the number congruency factor was the semantic relationship between target and distractor. To give an example, the singular target *Harke* 'rake' appeared once with each of the following distractor words: *Schaufel* 'shovel' (semantically related, number congruent), *Schaufeln* 'shovels' (semantically related, number incongruent), *Schleife* 'loop' (semantically unrelated, number congruent), and *Schleifen* 'loops' (semantically unrelated, number incongruent). The same conditions were applied to the plural target *Harken* 'rakes'. All target–distractor pairs were randomized and then divided into four blocks. Each block was randomized individually for each participant, and the order of blocks was varied. Between each block, there was a short break. The entire experiment took approximately 50 min.

Materials. Altogether, there were 48 black-on-white line drawings of common objects used as test pictures in the experiment (see Appendix B). In addition, there were eight practice pictures. The target pictures were taken from the picture database of the Max Planck Institute for Psycholinguistics. All selected picture names corresponded to monomorphemic German nouns. Most of the nouns were either monosyllabic or bisyllabic, but there were also some trisyllabic nouns. The mean frequency of occurrence per 1 million word forms (MANNHEIM corpus) was 28.8 for the targets as determined by CELEX. A total of 18 test targets formed the plural with -e, and 30 did so with -n. In addition, 9 test targets had neuter gender, 11 were masculine, and 28 were feminine. Distractor words were chosen such that they had no phonological relationship with the test targets. The mean frequency of occurrence per 1 million word forms was 14.4 for the semantically related distractors and 33.6 for the semantically unrelated distractors as determined by CELEX. The mean length in letters was 5.3 for the semantically related distractor words and 5.9 for the semantically unrelated distractor words. The two distractors for a particular target always had the same gender as the target and had at least the initial grapheme in common.

Results

One participant was excluded from the analyses due to extremely long RTs. There was an 18-ms effect of Semantic Relatedness: Pictures were named faster when the distractor words were semantically unrelated in meaning to the target (798 ms) than when they were semantically related (816 ms), $F_1(1, 16) = 17.22$, $MSE = 3212.20$,

$p < .01$; $F_2(1, 47) = 12.17$, $MSE = 9874.03$, $p < .01$. However, the effect of Number of Target (singular: 804 ms; plural: 809 ms) was significant by participants, $F_1(1, 16) = 13.73$, $MSE = 744.93$, $p < .01$, but not by items, $F_2(1, 47) = 2.19$, $MSE = 5261.64$, *ns*.[4] Again, there was no effect of Number of Distractor (singular: 805 ms; plural: 808 ms) $F_1(1, 16) < 1$; $F_2(1, 47) < 1$, nor was the interaction between the two variables significant. That is, there was no effect of Number Congruency, $F_1(1, 16) < 1$; $F_2(1, 47) = 2.62$, $MSE = 5008.19$, *ns*. Targets were named slightly slower in the number-congruent condition (808 ms) than in the number-incongruent condition (805 ms). None of the remaining interactions was significant.

Discussion

Experiment 2 did not reveal a number congruency effect, even though there is clear evidence of lexical processing of the distractor word. This seems to suggest that the selection of the diacritic parameter *number* is not a competitive process—at least in German. However, this conclusion may still be premature. Although we can be sure that participants processed the distractor words lexically, because we obtained a semantic interference effect, we cannot be sure that participants also processed the fact that the distractor words had been either in the singular or in the plural. Plural in German is marked at the end of words. Therefore, it may be the case that participants recognized the distractors without processing the ends of words. This possibility is not entirely implausible given that the distractor words were not particularly short. The mean lengths in letters of the distractors in the singular were 5.3 and 5.9 for the semantically related and unrelated distractors, respectively. It may well be that participants recognized most of the distractor words without encoding the number morphology, thereby undermining the possibility of obtaining a number congruency effect. However, the fact that umlaut plurals (which included a salient plural marking) in Experiment 1 behaved exactly like nonumlaut plurals makes this explanation implausible.

GENERAL DISCUSSION

This study investigated the role of the *number* feature in speech production. The number feature represents the grammatical category that specifies whether an entity is singular or plural (Bock & Eberhard, 1993). The question was whether or not number behaves in a similar way as gender. Several studies have shown that the gender feature of a distractor word influences the naming of a target noun in Dutch and German in the picture word interference task (La Heij et al., 1998; Schiller & Caramazza, 1999, submitted a,b; Schriefers, 1993; Schriefers & Teruel, 2000; Van Berkum, 1997) *when a determiner+noun NP has to be produced.* However, no effect of gender congruency effect is found in bare noun naming (La Heij et al., 1998; M. Miozzo & A. Caramazza, unpublished data). The latter results suggest that grammatical feature selection is not a competitive process and that the gender congruency effect observed in determiner+noun NP production reflects competition in determiner selection (Caramazza et al., 2001). However, it has been argued that the latter results are not relevant to the issues of grammatical feature selection because the gender feature is not selected in bare noun naming (Levelt et al., 1999). To resolve this issue, we investigated the effects of number congruency in the picture–word naming paradigm because the feature Number has to be selected even in the bare

[4] Comparison of the practice blocks (plain picture naming) revealed a 19-ms advantage for targets in the singular (789 ms) over targets in the plural (808 ms). However, this advantage was significant by participants, $t_1(16) = 2.29$, $SD = 31.56$, $p < .05$, but not by items, $t_2(47) = 1.41$, $SD = 217.13$, *ns*.

noun naming. The results clearly establish that grammatical features are not selected in a competitive process.

In Experiment 1, there was no difference in naming latencies between the number-congruent and number-incongruent conditions. The hypothesis that the number marking may have gone unnoticed because it is realized at the ends of words with inflectional suffixes is weakened by the fact that words with unlaut (i.e., stem alternation) in the plural behave similarly to words without such a salient marker. An effect of number congruency is also absent in the plural condition when there is no number marking on the distractor word in the singular.

Experiment 2 replicated the results of Experiment 1 with a different presentation procedure; instead of presenting one object in the singular and two in the plural, only one object was presented and the number condition was cued by presenting either the number 1 or the number 2. However, once again no effect of number congruency was obtained, although the semantic relatedness manipulation showed the expected interference effect. The latter effect is a signature of lexical processing of the distractor, and therefore we can rule out the possibility that the absence of a congruency effect is due to failure to process the distractor words lexically. Thus, we may conclude that the selection of the number diacritic in naming is a noncompetitive process. This encourages the more general conclusion that grammatical features in general, including gender, are also selected through a noncompetitive process.

If grammatical feature selection is a noncompetitive process, then how do we account for the gender congruency effect observed in Dutch and German NP production? It is possible that the so-called ''gender congruency effect'' is in fact a ''determiner congruency effect.'' Dutch and German both provide an interesting linguistic feature that allows distinguishing between grammatical feature selection and determiner form selection. These languages differentiate multiple genders by multiple determiners: common and neuter gender (*de* and *het*) in Dutch and masculine, feminine, and neuter gender (*der*, *die*, and *das*) in German. However, this is true only for the singular. In the plural, there is only one determiner form for all genders, namely, *de* in Dutch and *die* in German. This provides an ideal test case to contrast the competing hypotheses. If, as suggested by Schriefers (1993), grammatical feature selection is a competitive process, then effects of gender congruency should be obtained in the singular as well as in the plural (provided that the gender feature is selected). If, however, grammatical feature selection is not a competitive process (as suggested by our results on number selection) but determiner form selection is (as proposed by Caramazza et al., 2001, then congruency effects are expected in the singular but not in the plural. This latter result is expected because a choice between different determiner forms has to be made in the singular but not in the plural.

In a series of picture–word interference experiments in German and Dutch, Schiller and Caramazza (1999, submitted a,b) found significant interference effects from gender-incongruent distractor words in the singular but not in the plural. These interference effects were obtained in determiner+noun and determiner+adjective+noun naming, but only when a determiner had to be selected from a set of different determiners, that is, the singular. In the plural conditions, where only one determiner is produced for all genders, no interference effects were found. That is, a pure gender feature mismatch (without a concomitant determiner form mismatch) does not lead to interference in naming. These results clearly agree with the proposal that determiner selection is a competitive process, but they cannot be explained by those proposals that assume that grammatical feature selection is a competitive process.

In short, it seems that results from different studies are converging on a clear story: The gender congruency effect in Dutch and German (Schiller & Caramazza, 1999, submitted a,b; Schriefers, 1993; Schriefers & Teruel, 2000) is really a determiner congruency effect, but the selection of grammatical features is not a competitive process.

APPENDIX A
Stimuli Used in Experiment 1

Target picture	Lemma frequency	Distractor words (same plural formation as target)	Lemma frequency	Distractor words (different plural formation from target)	Lemma frequency	Gender
Bein ‘leg’	731	Rohr ‘tube’	62	Rad ‘wheel’	258	neu
Brot ‘bread’	174	Reh ‘roedeer’	28	Rind ‘cow’	98	neu
Flasche ‘bottle’	216	Made ‘maggot’	11	Mama ‘ma’	488	fem
Krone ‘crown’	159	Diele ‘hallway’	92	Diva ‘star’	1	fem
Puppe ‘doll’	52	Fahne ‘flag’	166	Faust ‘fist’	218	fem
Nase ‘nose’	211	Kiste ‘box’	132	Cola ‘coke’	—	fem
Schraube ‘screw’	28	Zunge ‘tongue’	86	Zunft ‘guild’	6	fem
Katze ‘cat’	105	Suppe ‘soup’	54	Sucht ‘addiction’	12	fem
Taube ‘pigeon’	76	Narbe ‘scar’	51	Nacht ‘night’	956	fem
Ziege ‘goat’	49	Lücke ‘gap’	0	Lust ‘joy’	182	fem
Kette ‘chain’	137	Wahl ‘election’	980	Wand ‘wall’	294	fem
Kasse ‘cash register’	308	Öse ‘loop’	7	Oma ‘grandma’	44	fem
Zelt ‘tend’	58	Bier ‘beer’	273	Bett ‘bed’	709	neu
Mond ‘moon’	461	Föhn ‘hair dryer’	9	Fels ‘rock’	72	mas
Zange ‘pliers’	18	Kohle ‘coal’	132	Kobra ‘cobra’	12	fem
Säge ‘saw’	15	Geige ‘violin’	16	Gans ‘goose’	21	fem
Pferd ‘horse’	387	As ‘ace’	15	Auto ‘car’	688	neu
Ente ‘duck’	125	Masse ‘mass’	408	Magd ‘maid’	26	fem
Schiff ‘ship’	575	Moor ‘bog’	28	Mofa ‘moped’	0	neu
Kirche ‘church’	1267	Schale ‘bowl’	27	Show ‘show’	31	fem
Pilz ‘mushroom’	30	Blick ‘view’	1049	Bauer ‘farmer’	307	mas
Bett ‘bed’	709	Ohr ‘ear’	292	Öl ‘oil’	211	neu
Helm ‘helmet’	22	Schnitt ‘cut’	74	Schurke ‘villain’	10	mas
Nonne ‘nun’	75	Flut ‘flood’	84	Frucht ‘fruit’	145	fem
Birne ‘pear’	23	Schnecke ‘snail’	0	Schnur ‘string’	22	fem
Vase ‘vase’	34	Salbe ‘ointment’	6	Sau ‘pig’	10	fem
Tasse ‘cup’	61	Kufe ‘runner’	3	Kuh ‘cow’	240	fem

Palme ‘palm tree’	20	Säule ‘column’	74	Sauna ‘sauna’	68	fem
Schere ‘scissors’	26	Mappe ‘folder’	37	Mutter ‘mother’	599	fem
Harke ‘rake’	9	Achse ‘axis’	58	Angst ‘fear’	608	fem
Hose ‘trousers’	138	Wunde ‘wound’	106	Wurst ‘sausage’	63	fem
Schlange ‘snake’	109	Beule ‘bump’	7	Bank ‘bank, bench’	541	fem
Spinne ‘spider’	33	Herde ‘cattle’	59	Haut ‘skin’	294	fem
Hund ‘dog’	203	Film ‘movie’	806	Fels ‘rock’	72	mas
Fisch ‘fish’	203	Keks ‘cookie’	7	Klub ‘club’	94	mas
Schwein ‘pig’	147	Beet ‘patch’	12	Brett ‘plank’	67	neu
Schaf ‘sheep’	83	Tor ‘goal’	425	Tal ‘valley’	144	neu
Tulpe ‘tulip’	7	Niere ‘kidney’	32	Nuss ‘nut’	24	fem
Wal ‘whale’	33	Rest ‘rest’	364	Rand ‘edge’	353	mas
Affe ‘monkey’	40	Riese ‘giant’	20	Ring ‘ring’	275	mas
Brief ‘letter’	847	Dieb ‘thief’	95	Drache ‘dragon’	25	mas
Rutsche ‘slide’	6	Nelke ‘pink’	24	Not ‘poverty’	250	fem
Bombe ‘bomb’	178	Miete ‘rent’	199	Maus ‘mouse’	57	fem
Harfe ‘harp’	5	Laube ‘summerhouse’	8	Laus ‘louse’	13	fem
Flöte ‘flute’	28	Kurve ‘bend’	144	Kunst ‘art’	661	fem
Kerze ‘candle’	61	Lüge ‘lie’	145	Luft ‘air’	648	fem
Pfeife ‘pipe’	64	Messe ‘fair’	214	Metro ‘metro’	10	fem
Arm ‘arm’	731	Bus ‘bus’	64	Bonze ‘big shot’	3	mas
Tisch ‘table’	599	Ort ‘place’	673	Ochse ‘ox’	30	mas
Schuh ‘shoe’	195	Blitz ‘lightning’	68	Bote ‘messenger’	12	mas

Note. neu, neuter; fem, feminine; mas, masculine. Words without entry in CELEX do not have a lemma frequency value (‘‘–’’).

APPENDIX B
Stimuli Used in Experiment 2

Target picture	Lemma frequency	Semantically related distractor words	Lemma frequency	Semantically unrelated distractor words	Lemma frequency	Gender
Brot ‘bread’	174	Steak ‘steak’	12	Studio ‘studio’	89	neu
Katze ‘cat’	105	Sau ‘pig (fem.)’	10	Safari ‘safari’	17	fem
Echse ‘lizard’	76	Kobra ‘cobra’	12	Koma ‘coma’	1	fem
Ziege ‘goat’	49	Kuh ‘cow (fem.)’	240	Kraft ‘strength’	2084	fem
Schaf ‘sheep’	83	Rind ‘cow’	98	Rad ‘wheel’	258	neu
Schwein ‘pig’	147	Lamm ‘lamb’	15	Loch ‘hole’	188	neu
Hund ‘dog’	203	Bär ‘bear’	47	Bandit ‘bandit’	45	mas
Birne ‘pear’	23	Ananas ‘pineapple’	9	Angst ‘fear’	608	fem
Fisch ‘fish’	203	Krake ‘octopus’	—	Kroate ‘Croat’	6	mas
Schuh ‘shoe’	195	Frack ‘tail coat’	6	Franke ‘franc, Franconian’	242	mas
Stier ‘bull’	51	Bison ‘bison’	2	Bikini ‘bikini’	22	mas
Kamel ‘camel’	15	Lama ‘llama’	5	Lasso ‘lasso’	12	neu
Zelt ‘tend’	58	Iglu ‘igloo’	1	Inferno ‘inferno’	7	neu
Mond ‘moon’	461	Komet ‘comet’	20	Kalif ‘caliph’	2	mas
Säge ‘saw’	15	Axt ‘axe’	22	Ankunft ‘arrival’	121	fem
Pferd ‘horse’	387	Kalb ‘calf’	43	Kind ‘child’	2503	neu
Ente ‘duck’	125	Gans ‘goose’	21	Geschwulst ‘growth’	7	fem
Bett ‘bed’	709	Sofa ‘couch’	40	Sandwich ‘sandwich’	5	neu
Helm ‘helmet’	22	Sombrero ‘sombrero’	1	Slogan ‘slogan’	9	mas
Ameise ‘ant’	28	Laus ‘louse’	13	Lust ‘desire’	182	fem
Kartoffel ‘potato’	152	Zucchini ‘zucchini’	—	Ziehharmonika ‘accordion’	15	fem
Karotte ‘carrot’	2	Paprika ‘pepper’	8	Party ‘party’	84	fem
Schiff ‘ship’	575	Kanu ‘canoe’	1	Kanapee ‘couch’	243	neu
Bein ‘leg’	731	Auge ‘eye’	1810	Album ‘album’	7	neu
Tasse ‘cup’	61	Gabel ‘fork’	26	Galle ‘gallbladder’	36	fem

Palme ‘palm tree’	20	Tanne ‘pine tree’	9	Tante ‘aunt’	196	fem
Schere ‘scissors’	26	Sichel ‘sickle’	11	Silbe ‘syllable’	38	fem
Harke ‘rake’	9	Schaufel ‘shovel’	25	Schleife ‘loop’	62	fem
Hose ‘trousers’	138	Jacke ‘jacket’	0	Jacht ‘yacht’	24	fem
Schlange ‘snake’	109	Kröte ‘toad’	7	Krise ‘crisis’	376	fem
Spinne ‘spider’	33	Biene ‘bee’	42	Beere ‘berry’	6	fem
Krone ‘crown’	159	Mütze ‘cap’	63	Mücke ‘mosquito’	0	fem
Puppe ‘doll’	52	Marionette ‘marionette’	32	Marmelade ‘jam’	17	fem
Tulpe ‘tulip’	7	Rose ‘rose’	87	Rolle ‘roll’	1010	fem
Zange ‘pliers’	18	Pinzette ‘tweezers’	2	Pistole ‘pistol’	82	fem
Kirche ‘church’	1267	Villa ‘villa’	117	Veranda ‘porch’	15	fem
Wal ‘whale’	33	Delphin ‘dolphin’	—	Dekan ‘dean’	34	mas
Affe ‘monkey’	40	Löwe ‘lion’	251	Lektor ‘lecturer’	25	mas
Rutsche ‘slide’	6	Schaukel ‘swing’	7	Scheibe ‘disc’	112	fem
Bombe ‘bomb’	178	Kanone ‘cannon’	30	Kapelle ‘chapel’	98	fem
Harfe ‘harp’	5	Posaune ‘trombone’	6	Position ‘position’	575	fem
Flöte ‘flute’	28	Trompete ‘trumpet’	42	Traube ‘grape’	19	fem
Kerze ‘candle’	61	Lampe ‘lamp’	57	Larve ‘larva’	8	fem
Pfeife ‘pipe’	64	Zigarre ‘cigar’	93	Zitrone ‘lemon’	19	fem
Arm ‘arm’	731	Hals ‘neck’	261	Hai ‘shark’	10	mas
Tisch ‘table’	599	Schrank ‘cupboard’	131	Schlauch ‘hose’	26	mas
Pilz ‘mushroom’	30	Baum ‘tree’	381	Bach ‘stream’	70	mas
Schraube ‘screw’	28	Nadel ‘pin’	34	Narbe ‘scar’	51	fem

Note. neu, neuter; fem, feminine; mas, masculine. Words without entry in CELEX do not have a lemma frequency value (‘‘–’’).

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