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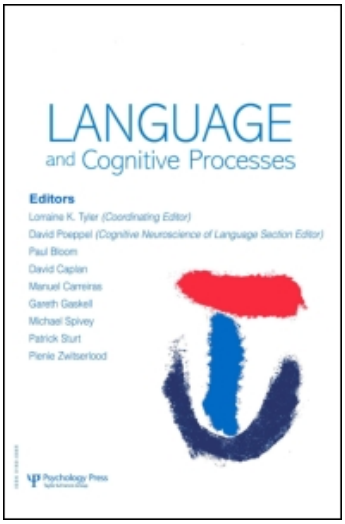

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Phonological facilitation of grammatical gender retrieval

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Phonological facilitation of grammatical gender retrieval

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In Dutch, the gender of nouns is marked by the definite articles *de* (common gender) and *het* (neuter gender). Most models of language production assume that gender information is retrieved via the noun's syntactic representation (or lemma). The authors test Caramazza's (1997) alternative proposal, according to which gender information is retrieved via the noun's phonological word form (or lexeme). In three picture–word experiments, which differed in the tasks to be performed (noun production, article+noun production, article production, and gender decision), clear phonological effects were obtained in tasks involving the retrieval of the noun's gender information. It is argued that traditional models of language production have difficulty in accounting for the occurrence and/or the size of these effects whereas they follow quite naturally from Caramazza's (1997) Independent Network model.

Many languages mark the grammatical gender of nouns. Modern Dutch distinguishes two genders: common gender (a combination of the Old Dutch feminine and masculine genders) and neuter gender. In the Dutch language the gender of a noun is marked in several ways, for example on

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the singular definite article (*het* for nouns of neuter gender, e.g., *het huis*, the house, and *de* for nouns of common gender, e.g., *de fiets*, the bike), on adjectives (*rood huis,* red house, vs. *rode fiets,* red bike), and on relative pronouns (*het huis dat* . . . , the house that . . . , versus *de fiets die* . . . , the bike that; see van Berkum, 1997).

Only recently psycholinguists have started to investigate how, during language production, gender marking is achieved (see Schriefers & Jescheniak, 1999, for a review). The models that are used in this research area often distinguish three levels of processing: a semantic level, a syntactic level, and a phonological level. Serial two-stage models of word production (e.g., Butterworth, 1989; Garrett, 1975) explicitly deal with the syntactic and the phonological levels. These models assume the corresponding modules to be informationally encapsulated (see Fodor, 1983), that is, the syntactic module is not affected by phonological processes and vice versa. Once the syntactic module has selected a word for production, it is phonologically encoded by the phonological module. Within such language production models, it seems only natural to localize the retrieval of a syntactic property such as the noun's gender at the syntactic level of processing. This is, for instance, the case in the language production model proposed by Levelt, Roelofs and Meyer (1999a; see Figure 1a) in which abstract representations of nouns (lemmas) are connected to *gender nodes*.

Gender nodes probably play a central role in the explanation of a finding that all models of language production should be able to account for: the *gender-congruency effect*. This effect was first reported by Schriefers (1993). In Schriefers' experiments the participants were presented with coloured pictures and were required to produce simple noun phrases such as *rood huis* (red house) or *rode kat* (red cat). The gender congruency effect refers to the observation that naming latencies were shorter when the target picture was accompanied by a noun of the same grammatical gender as the name of the picture (e.g., the context word *boek*, book) than by a noun of the alternative gender (e.g., the context word *boom*, tree). This gender congruency effect was replicated in the Dutch language by La Heij, Mak, Sander, and Willeboordse (1998) and van Berkum (1997) in a picture-naming task in which the participants had to produce definite article-noun phrases like *het huis* (the house) or *de kat* (the cat), and with a similar paradigm in the German language by Schriefers and Teruel (2000) and Schiller and Caramazza (2003). Note that the effect seems to be restricted to languages in which the grammatical gender of a word is independent of its phonological context. The effect is not obtained for languages in which this independence is absent (Alario & Caramazza, 2002; Costa, Sebastián-Gallés, Miozzo, & Caramazza, 1999; Miozzo & Caramazza, 1999; see Alario & Caramazza, 2002, for an account of determiner retrieval in various languages).

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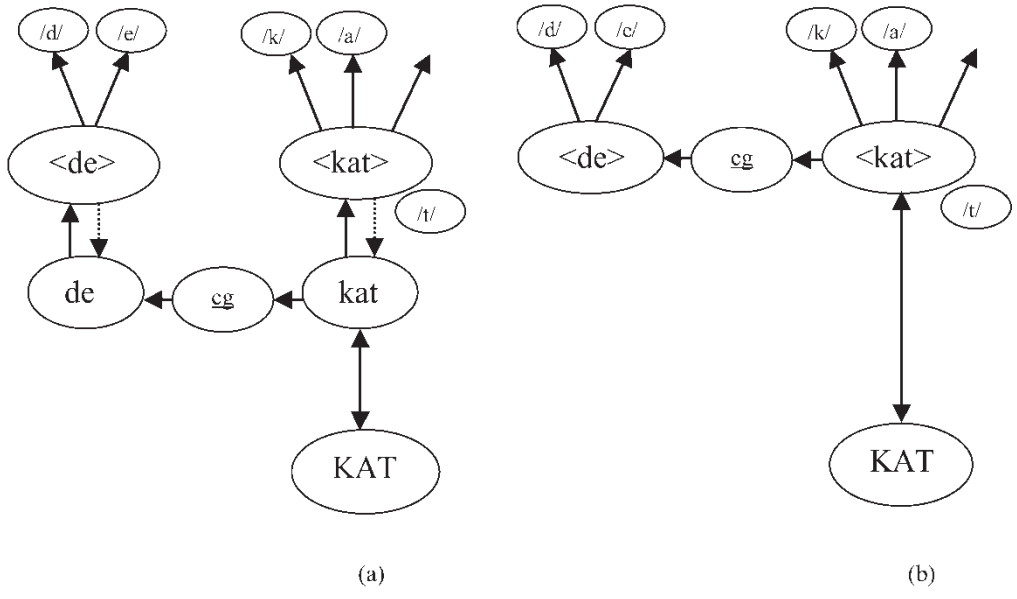

Figure 1. The retrieval of the definite determiner de corresponding to the Dutch word *kat* (cat) after presentation of a picture of a cat according to two classes of language production models. Nodes labelled with uppercase letters represent semantic information, nodes labelled with lowercase letters represent lemma information, nodes labelled with words in < > represent phonological information, and nodes labelled with letters in / / represent segment information. (a) Representations and links involved in the retrieval of the Dutch article *de* according to traditional models of language production. Solid arrows represent links involved in the retrieval of the Dutch article *de* via the noun's lemma and gender node in serial two-stage models of language production (e.g., Levelt et al., 1999a). The dotted arrows represent additional feedback links that are present in interactive models (e.g., Dell, 1986). (b) Representations and links involved in the retrieval of the Dutch article *de* via the noun's phonological representation according to Caramazza's (1997) Independent Network Model.
cg = common gender.

Levelt et al.'s (1999a) model accounts for the gender-congruency effect in the following way (see Figure 1a). The presentation of the target picture leads to the activation of the corresponding concept in semantic memory. Activation spreads from the target concept to the corresponding lemma and onwards to the lemma's gender node. A simultaneously presented context word activates its lemma and the corresponding gender node. If the task requires the retrieval of the gender of the name of the picture, the selection of the correct gender node takes less time in the case of congruent combinations (both words activate the same gender node) than in the case of incongruent combinations (the words activate different gender nodes). Note that according to this account gender selection can be bypassed and consequently no gender congruency effect should be obtained in a task in which the retrieval of grammatical gender is not required. This was empirically confirmed in an experiment by La Heij et al. (1998), in which naming a picture by a bare noun ('huis') instead of by an article and a noun ('het huis') eliminated the gender congruency effect.

Levelt et al.'s (1999a) detailed proposal to represent gender as a syntactic feature at a different level from word forms is intuitively appealing because it follows the formal distinction between a word's syntactic properties and its phonology. However, Roberts, Kalish, Hird, and Kirsner (1999) have argued that such a formal distinction need not imply corresponding lemma representations that are independent of word form representations. Indeed, as argued by Caramazza (1997), some syntactic characteristics (such as verb tense or grammatical category) may be activated directly from the semantic network, whereas others (like gender features) need the prior activation and selection of the corresponding word form node. The proposed mechanism to retrieve gender features shows that it is also conceivable that syntactic representations are not independent of word form representations. It should be noted, though, that the publication of Caramazza's (1997) independent network (IN) model caused immediate discussion in the literature. For example, Roelofs, Meyer, and Levelt (1998) raised several issues that seemed problematic for the IN model. However, in a reply Caramazza and Miozzo (1998) responded to these criticisms. In addition, Jescheniak and Levelt (1994) reported that after naming a picture twice using a gender-marked definite determiner noun phrase (e.g., participants named the picture of a cow with the phrase *de koe*), a name frequency effect did not show up in a subsequent gender decision task in which participants indicated the gender of the name of the picture by pressing one of two buttons. Based on this and other results, the authors argued that the standard effect of name frequency was localized at the word form level of language production. If we assume that this localization is correct (see Caramazza, Bi, Costa, & Miozzo, 2004; Caramazza, Costa,

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Miozzo, & Bi, 2001; Jescheniak, Meyer, & Levelt, 2003, for a recent debate about this issue), the IN model seems to have difficulties in explaining the lack of a frequency effect in gender decision because, according to the model, the retrieval of gender information is dependent on the retrieval of word form information. However, the critical finding of Jescheniak and Levelt (1994)—the absence of a frequency effect in gender decision after participants had named the pictures with a gender-marked noun phrase twice—did not replicate in an extensive and well-controlled study reported by van Berkum (1996, Experiment 2). Therefore, we will consider Caramazza's (1997) IN model as an equal alternative to the traditional models.

Although gender congruency effects in language production are reported in a substantial number of studies, the underlying mechanisms are not well understood. In the present article we tried to shed some light on these processes by studying what must be a basic routine in gender-marked languages: the retrieval of a noun's gender. As discussed above, the standard interpretation is that gender is retrieved via the noun's lemma, an abstract word representation that is not yet phonologically specified. However, as discussed above, the conception of Caramazza (1997) is also conceivable and will be discussed shortly.

To study this issue, we made use of a manipulation that has a long tradition in the language production literature. When a to-be-named picture (e.g., a picture of a cat) is accompanied by a phonologically (or orthographically) related distractor that shares its first letters with the name of the picture (e.g., *cap*), it is named faster than when it is accompanied by an unrelated distractor(e.g., *pen*). This result is called a phonological facilitation effect. Studies that report this effect generally agree that it originates at the word form retrieval level (see Figure 1). It is explained by assuming that the target word receives additional activation from the processing of a phonologically related distractor but not from the processing of an unrelated distractor. The additional activation facilitates target word form retrieval (e.g., Briggs & Underwood, 1982; Meyer, 1996; Meyer & Schriefers, 1991; Posnansky & Rayner, 1978; Rayner & Springer, 1986; Schriefers, Meyer, & Levelt, 1990; Starreveld & La Heij, 1995, 1996a, 1996b, 1999; Zwitserlood, 1994; see Starreveld, 2000, for a review). In the remainder of this article we call this the standard account of the phonological facilitation effect. Phonological facilitation effects can, however, also be localized at the level where the phonological segments that make up a word are retrieved (see Figure 1; see Starreveld, 2000, and Zwitserlood, 1994, for a discussion of these two possibilities).

In this article we used several variants of the picture–word task. In one variant, used in Experiment 1 and 2, participants only named the (gender-marked) definite determiner corresponding to the name of the picture

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(either *de* or *het*). This task clearly requires the retrieval of the noun's gender. We examined whether in this task a phonological facilitation effect could be obtained. If so, existing knowledge of the phonological facilitation effect (see Starreveld, 2000, for a brief review) may help to elucidate the characteristics of the processes involved in gender retrieval.

This issue is interesting because theories of language production vary in their ease of accounting for possible phonological effects on gender retrieval. Strict serial models of language production, as the one proposed by Levelt et al. (1999a), assume that a noun's gender is retrieved at the syntactic level. Due to the serial nature of these models, there is no feedback from the phonological level to the syntactic level of processing (see Butterworth, 1989; Garrett, 1975). These models only encompass the solid arrows of Figure 1a. Therefore, finding that gender retrieval processes are susceptible to phonological influences would be unexpected for this kind of model.

The most prominent difference between strictly serial and interactive models of language production (e.g., Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Harley, 1993; MacKay, 1987; Stemberger, 1985) is that in the latter kind of model there is a feedback link from the phonological level back to the lemma level (indicated by the dotted arrows in Figure 1a). These models might account for the occurrence of a phonological effect in gender retrieval because some of the additional activation that reaches the phonological representation of a noun due to processing of a phonologically related distractor might also reach the relevant gender node.

Finally, in the recently advanced IN model (Caramazza, 1997) no lemma representations are assumed. How then, are syntactic features retrieved? According to the model, some syntactic features (e.g., grammatical category and verb tense) can be activated from a semantic representation. However, 'with the exception of natural, gender-marked words (e.g., uomo [man] in Italian), gender features do not receive activation from the semantic network' (Caramazza, 1997, pp. 194–195). Instead, the gender feature of a noun can only be retrieved after the activation and selection of the noun's phonological word form (or 'lexeme'; see Figure 1b) has taken place. According to the standard account of the phonological effect, the retrieval of the word form is facilitated by a phonologically related distractor. Therefore this model predicts that a phonologically related distractor should also speed up the decision as to whether the name of a picture is a de-word or a het-word. In addition, even if the phonological effect is localized at the level of the phonological segments that make up the word, the same prediction can be made provided that interactivity is allowed between the segmental layer and the layer of phonological word forms (see Caramazza & Miozzo, 1998, for this suggestion). Therefore, the

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IN model can account for phonological effects in gender retrieval tasks quite easily.

All three experiments reported in this study used picture–word interference tasks in which the phonological relatedness between the distractor and the name of the target picture was the main independent variable. We used Dutch stimulus materials that were visually presented, and, in the related conditions, shared some (in the case of word distractors) or all (in the case of letter distractors) of their orthography with the target. Because Dutch has strong grapheme-to-phoneme consistency, the orthographically related pairs were also phonologically related. For ease of presentation, we use the term phonologically related throughout the article for these visually presented distractors. In Experiment 1 two tasks were used: noun-production and article-production (*de* or *het*). In line with the prediction derived from Caramazza's IN model, this experiment showed a phonological facilitation effect in the article-production task. The experiment also showed, somewhat surprisingly, that producing a bare article (e.g., *de*) took more time than producing a corresponding bare noun (e.g., *kat*).

In Experiment 2, the latter observation was further investigated. Three tasks were used: article production, noun production and article + noun production. This experiment revealed that article production was slower than article + noun production, which in turn was slower than the production of bare nouns. In addition, clear phonological effects were obtained for all three tasks, as in Experiment 1.

In the article naming tasks used in Experiments 1 and 2, participants might have developed a strategy of covertly producing an article and a noun because of the requirement to produce the articles verbally. To assess this possibility we included a manual gender decision task in Experiment 3. In the gender-decision task participants indicated by means of a button-press response whether the name of a picture was a 'de word' or 'het word'. Jescheniak and Levelt (1994) and Van Turennout et al. (1998) used this task and argued that it revealed processes taking place at the syntactic level of language production. Experiment 3 showed that phonological facilitation was also obtained with a manual gender decision task.

EXPERIMENT 1

Experiment 1 used a picture–word task in which participants either had to produce the name of the picture (a bare noun) or the article corresponding to the name of the picture (*de* or *het*; see van Berkum, 1997; La Heij et al., 1998; Schriefers, 1993). The experimental variables were: (a) gender congruency (the gender of the distractor word was identical to, or different from the gender of the name of the picture) and (b) phonological

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relatedness (the presence or absence of a phonological relation between the distractor word and the name of the target picture). The factorial combination of these variables resulted in four conditions. In addition, we used a control condition in which the distractors consisted of a series of five *x*s.

This experiment aimed at answering three questions. First, does the noun-production task show a phonological facilitation effect? If so, the possible lack of phonological facilitation in the article-production task cannot be attributed to a lack of phonological similarity in our stimulus materials. Second, does the article-production task show a gender-congruency effect? If so, we can safely conclude that our manipulations affected the syntactic level of processing which was also affected in the studies reported by Schriefers (1993), van Berkum (1997), and La Heij et al. (1998). Third, and most importantly, does the article-production task show a phonological facilitation effect? If not, this would provide compelling evidence in favour of traditional models in which retrieving a noun's gender does not necessarily involve retrieval of the noun's phonological representation (see Figure 1a). However, if a phonological facilitation effect is obtained, this would be completely in line with Caramazza's (1997) proposal that determiners are retrieved via the noun's phonological word form (see Figure 1b).

Method

Participants. Twenty-eight students of Leiden University served as paid participants. The participants in this and the following experiments all had normal or corrected-to-normal vision.

Materials. Thirty pictures were selected, most of which belonged to the set of 400 pictures that was described by Cycowicz, Friedman, Rothstein, & Snodgrass (1997). The pictures were line drawings of common objects. Each picture was drawn in black and was centred on a white background, which was 9.9 cm wide and 9.7 cm high. A small white border was created around the pictures. Half of the pictures had names of neuter gender, the other half had names of common gender. Each picture served in five distractor word conditions. (Dutch examples of distractors that accompanied the picture of a lamb (*het lam*) are given in parentheses. To illustrate the design of the study, we also include the articles belonging to the distractor words, but note that these were not presented.) For each picture, a word was selected that matched the name of the picture in the word-initial consonant-vowel combination and in its gender, to form the condition phon-gen (*het land*). These words were redistributed over the set of pictures to form a condition in which the words matched with the names

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of the pictures in gender but not in initial phonemes, to form the condition gen (*het kruid*). Also for each picture, a word was selected that matched with the name of the picture in its first consonant-vowel combination or first vowel but not in its gender, to form the condition phon (*de lat*). These words were matched with the words from the first condition in phonological similarity to the target, word length, and word frequency. Words from this set were redistributed to form the unrelated condition (*de kruik*) in which the words neither matched the names of the pictures in their gender nor in their initial phonemes. Finally, in the non-lexical control condition each picture was accompanied by a row of five *x*s. Distractors were drawn in black, lines were two pixels wide on a standard VGA display. Each line was surrounded by a white space of one pixel wide to improve readability. The height of the body of lowercase letters, excluding the ascenders and descenders, was 1.4 cm; ascenders and descenders were 0.6 cm each. The width of a *w* was 1.3 cm.

Within each task, each picture was presented five times, once for every condition. A complete list of the names of the target pictures, their gender, and the distractors is presented in Appendix A.

Two practice series were constructed. Practice series 1 consisted of the experimental pictures without distractors. To construct practice series 2, the experimental pictures were randomly divided in five groups, corresponding to the five conditions of the experiment. Each picture from each group was paired to a distractor that satisfied the constraints of the corresponding condition of the experiment. Thus, 30 practice distractors were used.

Apparatus. The experiment was programmed using MEL Professional software (version 2.0d; Schneider, 1988). Presentation of the stimuli and collection of the data were performed using a fast IBM compatible PC. The pictures were presented on a high-resolution monitor (NEC multisync M500). Reaction times were measured to the nearest ms by means of a voice key.

Procedure. Participants were seated in a dimly lit room, about 60 cm in front of a computer screen. They were presented a booklet that contained all target pictures. Below the pictures were their printed names preceded by the correct articles. Participants were asked to study the pictures and their names. Next, half of the participants were assigned to the noun-naming task and were asked to produce the name of the picture (a bare noun) as a response, the other half were assigned to the article-naming task and were asked to produce the article corresponding to the name of the picture. All participants received two practice series. First the material from practice series 1 was presented in random order and participants were

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asked to produce the response corresponding to the assigned task. Next they responded to the material from practice series 2, which was also presented in random order. Participants were instructed to respond as quickly and accurately as possible and to ignore the distractors, both in the second practice series and in the experimental series. In both practice series, picture-naming errors were corrected by the experimenter and the corresponding pictures were repeated at the end of the series. The task used in the two practice series was also used in the first experimental series. After the first experimental series the task was switched and practice series 2 was repeated, followed by the second experimental series.

For each participant, a pseudo-random order of trial presentation was created for each experimental series, in which presentations of a target picture were always separated by presentation of at least ten other pictures, in order to reduce possible repetition effects. In addition, this procedural aspect prevented the participants from using a short-term, or immediate, memory store to retrieve the names of the pictures (Miller, 1956). The experimental series started with three filler trials that functioned as warm-up trials. Filler trials were selected from the materials of practice series 2 in such a way that the selected filler pictures were not used in the next 10 experimental trials. For each task, presentation of the trials was administered in three blocks, and the participant was allowed a short break after each block. Whenever participants made an error, they were immediately corrected. Error trials and trials in which the voice key malfunctioned, were followed by a filler trial. Data from filler trials were not analysed.

The presentation of a trial involved the following sequence. First, a fixation point (+) appeared in the middle of a black screen, which was shown for 400 ms. Next the fixation point was erased and an empty screen was presented for 200 ms. Then the picture and the distractor were presented. The pictures were displayed centred on the screen. Distractors were displayed vertically centred around the point of fixation, and the first letter of the distractors was displayed slightly to the left of the point of fixation. The stimuli remained on the screen for 2 s and were replaced by a black screen. The experimenter then judged the response for correctness, noticing voice key failures, by typing a code into the computer. If a response was not provided in 2 s, the trial was judged as wrong. Subsequently the computer prepared the stimuli for the next trial. The experiment took about 30 minutes.

Results

All responses that were scored as incorrect and trials in which the voice key malfunctioned were removed from the analyses. This accounted for

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TABLE 1
Mean participants' reaction times (in ms) and error percentages for the various conditions and the two tasks used in Experiment 1, and effect sizes (in ms)

	Task			
	Noun production		*Article production*	
	RT	*% error*	*RT*	*% error*
Phon-Gen	727	1.2	833	2.1
Phon	714	0.7	869	3.0
Gen	784	1.2	867	1.0
Unrelated	786	1.5	886	1.5
Control	689	0.8	831	2.6
Phon effect	65		26	
Gender effect	−6		28	

Note. Phon-Gen = phonologically related and gender congruent; phon = phonologically related; gen = gender congruent; phon effect = (unrelated + gen) − (phon + phon-gen); gender effect = (unrelated + phon) − (gen + phon-gen).

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1.6% and 2.1% of the data, respectively. The remaining reaction times were used for the calculation of the means for the five conditions of each task. The participant means and the corresponding error percentages are presented in Table 1. In this and in the following experiments, the error percentages were considered too low to perform meaningful error analyses.

An analysis of variance (ANOVA) was performed on the participant means, with task and condition as within-subjects variables (F_1). The same analysis was performed using the item means (F_2). A significant effect of task was obtained, $F_1(1, 27) = 58$, $p < .001$, $MSE = 16624$; $F_2(1, 29) = 130$, $p < .001$, $MSE = 7981$. Participants responded faster in the noun-naming task than in the article-naming task. Also, a significant effect of condition was obtained, $F_1(4, 108) = 33.4$, $p < .001$, $MSE = 1660$; $F_2(4, 116) = 33.2$, $p < .001$, $MSE = 1846$. Finally the interaction of task and condition was significant, $F_1(4, 108) = 14.3$, $p < .001$, $MSE = 881$; $F_2(4, 116) = 13.6$, $p < .001$, $MSE = 1062$, indicating a different pattern of results for each task. Next we evaluated the obtained pattern of results separately for each task. ANOVAs were performed with phonological relatedness and gender congruency, each with two levels, as within-subjects variables.

Noun production. For the noun production task, a highly significant effect of phonological relatedness was obtained, $F_1(1, 27) = 49$, $p < .001$, $MSE = 2358$; $F_2(1, 29) = 43$, $p < .001$, $MSE = 3107$. Pictures accompanied

by phonologically related words were named faster than pictures that were accompanied by unrelated words. There was no effect of gender congruency, $F_1(1, 27) = 1.05$, $p > .3$, $MSE = 824$; $F_2(1, 29) = 0.58$, $p > .4$, $MSE = 1646$. There was no interaction of these two variables, although there was a trend in the participant analysis, $F_1(1, 27) = 3.8$, $p < .1$, $MSE = 402$; $F_2(1, 29) = 1.28$, $p > .2$, $MSE = 1399$.

Article production. For the article production task, the effect of phonological relatedness was again significant, $F_1(1, 27) = 9.3$, $p < .01$, $MSE = 1905$; $F_2(1, 29) = 19$, $p < .001$, $MSE = 1012$. Pictures accompanied by phonologically related words were named faster than pictures accompanied by unrelated words. However, in this task there was also a clear effect of gender congruency, $F_1(1, 27) = 17$, $p < .001$, $MSE = 1244$; $F_2(1, 29) = 22$, $p < .001$, $MSE = 1145$. Pictures accompanied by words of the same gender were named faster than pictures that were accompanied by words of a different gender. Finally, there was no interaction of these two variables $F_1(1, 27) = 2.5$, $p > .1$, $MSE = 769$; $F_2(1, 29) = 1.2$, $p > .2$, $MSE = 1679$.

Discussion

In the noun production task, an effect of phonological relatedness was obtained. This result replicates the findings of many other studies (e.g., Briggs & Underwood, 1982; Starreveld, 2000). In this task no gender-congruency effect was obtained. This finding corroborates results reported by La Heij et al. (1998), who reported the absence of gender congruency effects in bare-noun naming.

In the article production task, a clear gender-congruency effect was obtained. This finding indicates that our article-production task was sensitive to reveal processes involved in gender retrieval (see also van Berkum, 1996, 1997; La Heij et al., 1998; Schriefers, 1993). Finally, and most importantly, the article production task showed a clear effect of phonological relatedness. That is, the retrieval of the article corresponding to a noun was facilitated when the retrieval of the noun's phonological representation was facilitated, completely in line with the prediction that we derived from Caramazza's (1997) IN model (see also Figure 1b).

We did not obtain an interaction between the variables gender congruency and phonological relatedness, although according to the IN model (Caramazza, 1997) an interaction of these variables might be expected. However, at least two reasons can be given for the lack of an interaction. First, in Experiment 1 we used words as distractors. Phonologically related words, however, also include unrelated letters that might cause interference and thus obscure facilitatory phonological effects.

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In the next experiments we used word parts in order to deal with this issue. Second, numerically there is an interaction (the phonological effect is 17 ms in the gender incongruent conditions and 34 ms in the gender congruent conditions), although it failed to reach significance. This might in part be attributed to the fact that multiplicative interactions in a 2 × 2 design are particularly difficult to detect (Wahlsten, 1991; see also Sohn, 1992).

An unexpected observation in Experiment 1 was that the response latencies in the article-production task were longer than those obtained in the bare-noun production task. In the control condition the difference in the reaction times between tasks was 142 ms. In Experiment 2 we further investigated this finding.

EXPERIMENT 2

In the article production task, participants produced words of a very high frequency. Nevertheless, we found in Experiment 1 that naming times for bare articles were longer than naming times for bare nouns. Several reasons might be given for this difference. For example, the longer reaction times in the article production task might reflect specific aspects of article production, like the time needed to select the correct gender and the lemma of the article. Alternatively, the longer reaction times in the article production task might reflect additional processes that are specific for the task. It is possible that in order to produce a bare article, participants had to prevent the corresponding noun also being produced. This might have occurred by inhibiting language production processes concerned with the production of that noun, part of which had driven the article production process. This might also have occurred by selecting an article from a covertly produced determiner noun phrase. In Experiment 2 we evaluated these possibilities by including a third task in which participants named both the article and the noun. If the longer reaction times in the article production task reflect specific aspects of article production, then reaction times for the article + noun production task should be similar to or even longer than reaction times in the article production task. If, however, the longer reaction times in the article production task are specific for that task, then reaction times for the article + noun production task should be shorter than the reaction times in the article production task.

In addition, to allow for another test between models that assume lemma-based gender retrieval (see Figure 1a) and Caramazza's (1997) IN model that assumes lexeme-based gender retrieval (see Figure 1b), we again examined the influence of phonological similarity between a distractor and the name of the picture on gender retrieval. However, in

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the present experiment an attempt was made to obtain a purer estimate of the size of this effect than the one obtained in Experiment 1. The phonological facilitation effect obtained in Experiment 1 (defined as the difference between the unrelated word condition and the phonologically related word condition) is not an appropriate estimate, because it is made up of at least three components: (a) the first letters of a phonologically related distractor facilitate target name retrieval as compared with an unrelated distractor, but (b) the first letters of an unrelated distractor inhibit target name retrieval as compared with a non-lexical control stimulus. In addition (c) the end letters of both phonologically related and unrelated distractors inhibit target name retrieval as compared with a non-lexical control stimulus.

To obtain a better estimate of the facilitation component mentioned under (a), in the present experiment only the initial letter or initial letters of the name of the target picture were used as distractors. For example, the picture of a knife (*mes*) was accompanied by the distractor letter *m* in the related condition, the distractor letter *w* in the unrelated condition, and by the distractor *xx* in the control condition. This choice of materials eliminates the contribution of component (c) mentioned above. However, reaction times for the unrelated condition still include component (b), which might render the unrelated condition an unsuitable baseline for an unbiased estimate of the influence of overlapping letters between a distractor and the name of the picture. We return to this issue in the discussion of this experiment.

It should be noted that the use of letter strings as distractors in the picture-word task is not new: nonwords have been shown to induce phonological facilitation (Posnansky & Rayner, 1977; Rayner & Posnansky, 1978; Schriefers & Teruel, 1999; Starreveld, 2000). As will be explained in the General Discussion, the results of this experiment will help evaluate the relative merits of various language production models (serial models, interactive models, and the IN model).

Method

Participants. Eighteen students of Leiden University served as paid participants.

Materials. The pictures used were the same as those used in Experiment 1. Three distractor conditions were used, phon (phonologically related), unrelated, and control. The non-words for the phon condition and for the unrelated condition were derived from the words used in the conditions phon-gen and gen of Experiment 1 and consisted of only the first consonant(s) or first vowel of these words. Therefore, the set

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of non-words was the same for the two conditions, only the pairings between non-words and pictures differed. For example, the picture of a *flag* was accompanied by the distractor *fl*, or an unrelated distractor *s*, and the picture of a *sock* was accompanied by the distractor *s*, or an unrelated distractor *fl*. Mean distractor length was 1.5 letters. The control condition consisted of 2 *x*s. A complete list of the targets and distractors is presented in Appendix A.

As in Experiment 1, two practice series were constructed. Practice series 1 consisted of the experimental pictures without distractors. To construct practice series 2, the experimental pictures were randomly divided into three groups. The pictures of one group were paired to related non-words, the pictures of another group were paired to unrelated non-words and the pictures of the final group were paired to 2 *x*s.

Apparatus. The apparatus was the same as in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1, except that now one-third of the participants started with the noun production task (e.g., response: *kat*), one-third started with the article production task (e.g., response: *de*), and one third started with the definite determiner noun phrase production task (e.g., response: *de kat*). Each participant performed the three different naming tasks, the sequence of which was counterbalanced. As in Experiment 1, the first experimental series of each participant was preceded by both practice series 1 and 2. The remaining experimental series were preceded by practice series 2 only. The experiment took about 30 minutes.

Results

All responses that were scored as incorrect and trials in which the voice key malfunctioned were removed from the analyses. This accounted for 1.9% and 2.5% of the data, respectively. The remaining reaction times were used for the calculation of the means for the three conditions of each task. The participant means and the corresponding error percentages are presented in Table 2. Next, paired *t*-tests were performed on the participant means to evaluate the effect of phonological relatedness for all three tasks (t_1). The same tests were performed using the item means (t_2).

Noun production. For the noun production task, a highly significant effect of phonological relatedness was obtained, $t_1(17) = 6.5$, $p < .001$; $t_2(29) = 5.2$, $p < .001$.

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TABLE 2
Mean participants' reaction times (in ms) and error percentages for the various conditions and the three tasks used in Experiment 2, and effect sizes (in ms)

	Task					
	Noun production		*Article production*		*Noun-phrase production*	
	RT	*% error*	*RT*	*% error*	*RT*	*% error*
Phon	679	1.1	836	3.0	740	2.6
Unrelated	757	1.3	871	2.0	793	2.0
Control	706	1.7	854	2.6	768	1.1
Unrelated—Phon	78		35		53	
Control—Phon	27		18		28	

Note. Phon = phonologically related.

Article production. For the article production task, the effect of phonological relatedness was again significant, $t_1(17) = 3.8$, $p < .01$; $t_2(29) = 2.6$, $p < .05$.

Noun phrase production. Finally, for the noun phrase production task, the effect of phonological relatedness was also significant, $t_1(17) = 5.6$, $p < .01$; $t_2(29) = 4.3$, $p < .05$.

All tasks. In addition, we performed ANOVAs to evaluate whether the size of the phonological facilitation effect relative to the unrelated condition differed for the three tasks used. The ANOVAs had two within-subject variables, phonological relatedness with two levels and task with three levels. The effect of task was significant, $F_1(2, 34) = 23$, $p < .001$, $MSE = 7363$; $F_2(2, 58) = 81.2$, $p < .001$, $MSE = 3397$. The effect of phonological relatedness was also significant, $F_1(1, 17) = 94.6$, $p < .001$, $MSE = 873$; $F_2(1, 29) = 38.3$, $p < .001$, $MSE = 3677$. In addition, the interaction of these two variables was significant, $F_1(2, 34) = 4.5$, $p < .05$, $MSE = 977$; $F_2(2, 58) = 3.6$, $p < .05$, $MSE = 2336$. Newman-Keuls post-hoc analyses showed that the phonological effect obtained in the noun production task was larger than the one obtained in the article production task (both ps $< .05$). In addition, the difference in the effect size between the noun production task and the noun phrase production task was marginally significant (both ps $< .1$).

To evaluate the phonological facilitation effects relative to the control ('xx') condition we performed the same ANOVAs. Again, the variable task was significant, $F_1(2, 34) = 26.1$, $p < .001$, $MSE = 8150$; $F_2(2, 58) = 105$, $p < .001$, $MSE = 3316$. The effect of phonological relatedness was also significant, $F_1(1, 17) = 43.6$, $p < .001$, $MSE = 364$; $F_2(1, 29) = 18.1$,

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$p < .001$, $MSE = 1431$. However, these variables showed no interaction, both ps $> .6$.

Finally we evaluated whether the mean reaction times differed for the three tasks. To do so, we calculated the mean reaction time for each task and performed ANOVAs on these means with one within-subject variable, task, with three levels. The effect of this variable was significant, $F_1(2, 34) = 24.9$, $p < .001$, $MSE = 3586$; $F_2(2, 58) = 117$, $p < .001$, $MSE = 1249$. Newman-Keuls post-hoc analyses showed that the mean reaction times of the three tasks differed from each other, both in the participant analysis and in the item analysis (all ps $< .05$). The noun production task produced the fastest mean reaction time, followed by the noun phrase production task. The article production task produced the slowest mean reaction time.

Discussion

This experiment showed clear phonological facilitation effects both in the noun production task and in the two tasks involving gender retrieval (article production and article + noun production). So, the results replicated the phonological facilitation effect observed in the article-naming task of Experiment 1. In addition, phonological effects were obtained in the article + noun production task. Similar results have been reported by Costa and Caramazza (2002), Jescheniak, Schriefers, and Hantsch (2003), Meyer (1996), and Miozzo and Caramazza (1999), although in those studies whole words were used as distractors.

The present experiment allowed a within-participants comparison of the results of three tasks. Three interesting findings were obtained: (a) article production took more time than article + noun production, (b) the size of the phonological facilitation effect, defined as the difference between the phonologically related and control condition was very similar in the three tasks investigated, and (c) article + noun production took more time than noun production. We now briefly discuss these findings in turn.

First, an important reason to include the article + noun production task was to evaluate whether the long reaction times in the article production task of Experiment 1 reflected additional time specific to article production, or whether they reflected task-specific processes. The present results showed that the overall mean naming latency in the article production task (854 ms) was substantially larger than the mean naming latency in the article + noun production task (767 ms). In a number of studies that used gender decision tasks (Jescheniak & Levelt, 1994; Van Turennout et al., 1998), the critical assumption was made that speakers are able to produce a response as soon as a gender node is selected (be it a verbal or a manual response, cf. our next experiment). It is therefore unclear why the production of a bare article should take longer than the

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production of an article and the corresponding noun. Without additional assumptions, this observation cannot be explained by any present model of language production.

One way of explaining the long reaction times in the bare article production task is to assume that speakers possess a monitor that rejects agrammatical utterances. In the case of the production of bare articles, this monitor might try to prevent the utterance from being produced, prolonging reaction time. Note, however, that this explanation is independent of the interpretation of the obtained phonological effects in this task because such a monitor would probably just add a constant amount of processing time, irrespective of the different conditions used.

Another way of explaining the long reaction times in the bare article production task is to assume that the origin of the effect is task specific. In order to produce a bare article participants might have had to prevent the production of the corresponding noun. In terms of lemma-based gender retrieval models, one could argue that the further processing of the lemma had to be prevented or, if that option was not open to strategic control, the phonological encoded lemma should not have been produced. This latter process might have involved the selection of the article from a covertly produced article-noun phrase or the inhibition of the noun's phonological representations. In terms of Caramazza's (1997) IN model, an article is retrieved via the phonological representation of the corresponding noun. As a consequence, it is impossible not to retrieve the phonology of the noun, even when only an article had to be produced. The longer response latencies in the article-production task may then reflect the time to select that article from a covertly produced article-noun phrase or to inhibit the already retrieved phonological representation of the noun. The idea that the phonological representation of the name of the target was also retrieved in article naming is also in accordance with the introspection of our participants, who sometimes remarked that they were unable to determine whether the name of a picture was a de-word or a het-word without retrieving the name of the picture.

The second finding that is worth discussion was the observation that the mean reaction times for the phonologically unrelated condition were strongly affected by task difficulty (see Table 2). In comparison with the control condition, interference induced by the unrelated letters was strongest in the fastest task (noun production: 51 ms) but dropped to only 17 ms at the slowest task (article production). Thus, the amount of competition due to the non-overlapping letter(s) of the phonologically unrelated distractor stimuli—component (b) discussed in the introduction of this experiment—varied strongly between tasks. We do not know of a language production theory that accounts for this phenomenon, but it

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indicates that a measure of phonological facilitation defined as the difference between the related condition (e.g., the picture of a knife—response *mes*—with the distractor *m*) and the unrelated condition (e.g., the picture of a knife with the distractor *w*) is inadequate for our present purposes.

The phonological facilitation effect defined as the difference between the related condition (e.g., the picture of a knife—response *mes*—with the distractor *m*) and the *control* condition (e.g., the picture of a knife with the distractor *xx*) seems much more suited to evaluate possible differences between the size of the phonological facilitation effects obtained in the three tasks. The important result of the present experiment—to which we return in the General Discussion—is that the phonological facilitation effects defined in this way did not differ statistically between the three tasks used (27 ms, 18 ms, and 28 ms, in the noun-production, article-production, and article + noun production tasks, respectively).

The third observation of interest in the present experiment was that the mean reaction time in the article + noun production task (767 ms) was longer than in the bare noun production task (714 ms). This finding replicates results reported by La Heij et al. (1998). However, several authors have reported the opposite pattern. Costa and Caramazza (2002, Experiment 1) reported faster naming times in an article + noun production task than in a bare noun production task. Because participants in this latter study responded in English, this finding might be attributed to the fact that in English the selection of the article can, in principle, be achieved independent of the selection of the noun. However, in other studies (Jescheniak et al., 2003; Miozzo & Caramazza, 1999; Schriefers, Jescheniak & Hantsch, 2002) participants responded in Italian or German, languages in which the selection of an article cannot be achieved independent of the noun. Nevertheless, these studies also reported (numerically) faster reaction times in the article + noun production tasks than in the bare noun production tasks.[1] At present it is unknown why we obtained the opposite pattern.

EXPERIMENT 3

In the article-production tasks used in Experiment 1 and 2 verbal responses were required. This requirement may have induced a strategy

[1] The finding of faster naming times in an article+noun production task than in a noun production task is, in itself, puzzling for all languages in which the article form depends on the gender of the noun. Why would it be easier to produce an utterance that involves an additional article production process than to produce an utterance that only involves the production of a bare noun? Putted differently, how can the production of the article facilitate the production of the corresponding noun? This issue certainly deserves further research.

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to covertly produce both the article and the noun and to select the definite article from that phrase for production. In fact, some of the participants in these experiments reported that this was the only way to perform the task, and the fact that in Experiment 2 reaction times in the bare article production task were longer than in the article + noun production task also points in this direction. Nevertheless, in previous studies on Dutch gender production the claim was made that Dutch speakers have direct access to abstract gender representations. Typically, in these studies (Jescheniak & Levelt, 1994; Van Turennout et al., 1998) participants performed a gender-decision task in which a manual response was required.

To investigate whether the phonological facilitation effects observed in Experiments 1 and 2 are due to the use of verbal responses, in Experiment 3 both a manual-response gender-decision task was used and a noun-naming task. In addition, to determine whether the results of Experiments 1 and 2 generalise to other stimuli, new materials were selected for Experiment 3. Finally, Jescheniak and Levelt (1994) obtained their critical results—the absence of frequency effects in gender decision—only when pictures were presented for the third time (Experiment 4 and 5b). To make our results comparable with this study, our participants performed the gender decision task twice in the practice series.

Method

Participants. Twelve students of the Vrije Universiteit served as paid participants.

Materials. A new set of 30 pictures was used for this experiment. The pictures used were drawn from the same sources as in Experiment 1. Again, non-words were used as distractors. As in Experiment 2, the non-words in the phon condition consisted of the first consonant(s) or the first vowel of the picture names. These non-words were redistributed over the set of pictures to form the unrelated condition. The mean length of the distractors was 1.3 letters. The same control condition was used as in Experiment 2. Therefore, three conditions were used, phon (phonologically related), unrelated, and control (2 *x*s). A complete list of the materials is presented in Appendix B.

Apparatus. The apparatus was the same as in Experiment 1. In addition, reaction times to key presses were measured to the nearest millisecond by means of a response box.

Procedure. The procedure was very similar to that of Experiment 1. Participants performed a noun production task (e.g., response: *kat*) and, in

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a different block of trials, a gender decision task. The gender decision task differed from the one used in Experiment 1 in that the participants did not produce the article corresponding to the name of the picture (*de* or *het*), but indicated whether the name of the picture was of common gender or neuter gender by pressing one of two buttons on the response box. Button assignment as well as order of tasks were counterbalanced across participants. In addition, two practice series were constructed in a similar way as in Experiment 2. The experimental series of each task was preceded by both practice series, to facilitate a comparison with the results of Jescheniak and Levelt (1994) and because pilot work had shown that gender decision required a little more practice than the article-production task of Experiment 1. The experiment took about 30 minutes.

Results

All responses that were scored as incorrect and trials in which the voice key malfunctioned were removed from the analyses. This accounted for 2.8% and 1.2% of the data, respectively. The remaining reaction times were used for the calculation of the means for the three conditions of each task. The participant means and the corresponding error percentages are presented in Table 3. Paired *t*-tests were performed on the participant means to evaluate the effect of phonological relatedness for each task. The same tests were performed using the item means.

Noun production. For the noun production task, a highly significant effect of phonological relatedness was obtained, $t_1(11) = 5.0$, $p < .001$; $t_2(29) = 7.6$, $p < .001$.

TABLE 3
Mean participants' reaction times (in ms) and error percentages for the various conditions and the two tasks used in Experiment 3, and effect sizes (in ms)

	Task			
	Noun production		*Gender decision*	
	RT	*% error*	*RT*	*% error*
Phon	562	0.6	666	3.6
Unrelated	633	1.7	697	5.0
Control	595	0.8	681	5.0
Unrelated—Phon	71		31	
Control—Phon	33		15	

Note. Phon = phonologically related.

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Gender decision. For the gender decision task, the effect of phonological relatedness was also highly significant, $t_1(11) = 3.4$, $p < .01$; $t_2(29) = 3.6$, $p < .01$.

Both tasks. Finally, ANOVAs were performed to evaluate whether the effect of phonological relatedness differed for the two tasks. The ANOVAs had two within-subjects variables, task with two levels (noun production and gender decision) and phonological relatedness with two levels (unrelated and phonologically related). The effect of task was significant, $F_1(1, 11) = 17.9$, $p < .01$, $MSE = 4724$; $F_2(1, 29) = 53$, $p < .001$, $MSE = 4007$. Participants responded faster in the noun production task than in the gender decision task. The effect of phonological relatedness was also significant, $F_1(1, 11) = 25.1$, $p < .001$, $MSE = 1240$; $F_2(1, 29) = 75.1$, $p < .001$, $MSE = 1104$. Participants responded faster in the phon condition than in the unrelated condition. Finally, the interaction of these two variables was significant, $F_1(1, 11) = 10.1$, $p < .01$, $MSE = 457$; $F_2(1, 29) = 8.9$, $p < .01$, $MSE = 1448$, indicating that the phonological facilitation effect was smaller in the gender decision task than in the noun production task.

Next, we evaluated the phonological relatedness as defined relative to the control condition (in which the string 'xx' was used as the distractor). The same ANOVAs were performed to evaluate whether this phonological relatedness effect differed between the two tasks. Again, the effect of task was significant, $F_1(1, 11) = 16.8$, $p < .01$, $MSE = 6510$; $F_2(1, 29) = 73.5$, $p < .001$, $MSE = 3782$. The effect of phonological relatedness was also significant, $F_1(1, 11) = 14.6$, $p < .01$, $MSE = 481$; $F_2(1, 29) = 15.7$, $p < .001$, $MSE = 1176$. However, the interaction of these two variables now failed to reach significance (both ps $> .1$).

Because half of the participants performed the noun production task before they performed the gender decision task, the possibility exists that these participants also, but now covertly, produced a noun in the gender decision task. If this strategy was responsible for the obtained phonological facilitation effects in the gender decision task, participants who started with the noun production task should show phonological facilitation in this task, whereas participants who started with the gender decision task should not show the effect. In order to evaluate this possibility two additional ANOVAs were performed on the participant means with one between-subjects variable, task sequence with two levels (gender decision first or second) and two within-subjects variables, task and phonological relatedness. The first ANOVA evaluated the phonological relatedness as defined relative to the unrelated condition, and the second ANOVA evaluated the phonological relatedness as defined relative to the control condition. Neither the effects of task sequence, nor the second order, nor the third

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order interactions with this variable were significant (all *p*s > .25), indicating that there were no effects of task sequence present in the results. In fact, numerically, participants who started with the gender decision task produced larger phonological effects for both tasks than those who started with the naming task, so the strategy sketched above could not have caused the phonological effects in the gender decision task.

Error percentages in the gender decision task seemed somewhat higher than in all naming tasks reported in this study. However, since in the gender decision task the phonologically related condition showed fewer errors than the unrelated and control conditions, no speed–accuracy trade-off effects were apparent.

Discussion

The results of the noun production task showed clear phonological facilitation effects. These results show that the new materials used in Experiment 3 were suitable to address the question at hand with our manual-response gender-decision task. We obtained a reliable phonological facilitation effect in this task. It has been argued that the manual gender decision task directly reflects processing at the syntactic level (Jescheniak & Levelt, 1994; Van Turennout et al., 1998). For example, Jescheniak and Levelt (1994) did not obtain a frequency effect in such a task when the pictures were presented for the third time. Based on this and other results they argued that frequency information is not encoded in the activation thresholds of lemmas. In our experiment, pictures were presented twice in the practice series of each task. Thus, in our experimental series, pictures were presented at least for the third time, making our design comparable with that of Jescheniak and Levelt (1994) in this respect. The fact that we obtained a reliable phonological facilitation effect in our task shows that phonological facilitation in gender production is not confined to the use of verbal naming responses.

GENERAL DISCUSSION

Traditional models of language production assume that a noun's gender is retrieved via an abstract word representation, the noun's lemma, which is not yet phonologically specified (see Figure 1a). In contrast, in his Independent Network Model, Caramazza (1997) proposed that gender is retrieved via the noun's phonological word form (see Figure 1b). In three picture–word interference experiments we tested a rather straightforward prediction that can be derived from Caramazza's proposal. This prediction is that a manipulation that facilitates the phonological encoding of the

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name of a target picture should facilitate the retrieval of the grammatical gender of that name.

In Experiment 1 we replicated the gender-congruency effect reported by Schriefers (1993) and La Heij et al. (1998), which was taken as evidence that our manipulation affected the same processing level as these earlier studies. In Experiments 1, 2, and 3, three different gender-retrieval tasks were used: article production (either *de* or *het*), article + noun production (e.g., *de kat* or *het boek*), and gender-decision with button-press responses. Completely in accordance with the prediction that we derived from Caramazza's (1997) IN model, in all three tasks clear phonological facilitation effects were obtained.

However, upon deeper consideration, several questions remain. For example, in all of our experiments we obtained smaller phonological facilitation effects (defined as the difference in reaction time between the unrelated and the phonologically related condition) in our gender-retrieval tasks that required the retrieval of the article's phonology than in the noun-naming task that only required the retrieval of the noun's phonology. In Caramazza's (1997) IN model, speakers always retrieve the gender of the noun after the retrieval of the noun's phonology. Therefore, this model seems to predict equal phonological effects for all the tasks used.

This prediction cannot be evaluated properly by analysing the results of Experiment 1. In this experiment, whole words were used as distractors. As a consequence, the phonologically related distractors contained both related letters and unrelated letters. As argued in the introduction of Experiment 2, the presence of unrelated letters complicates the interpretation of the phonological effects obtained in Experiment 1. Whereas the related letters most probably helped the retrieval of the noun's phonology, the unrelated letters most probably hampered this process. The net result of these two effects (facilitation and interference) showed up as facilitation when compared with the unrelated condition, but as interference when compared with the control condition (which used xs as distractors). The fact that interference of the phonologically related conditions was obtained relative to the control condition (which used xs as distractors) strongly indicates that the interference of unrelated letters that were present in our phonologically related distractor words was considerable.

In order to disentangle the facilitating and interfering consequences of the presence of phonologically related words, we used word-part distractors in Experiment 2. In the phonologically related condition these distractors contained only the identical begin-letters of the picture name whereas unrelated letters were used as distractors in the unrelated condition. A comparison of the results for these conditions with a control condition in which the distractors consisted of *x*s allows a separate

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evaluation of facilitation and interference effects. The results of Experiment 2 showed that the identical letters produced clear facilitation. In addition these effects were statistically of the same size for each of the three tasks used. In contrast, the unrelated letters produced clear interference. In addition, these effects decreased from 51 ms in the noun production task to 17 ms in the article production task.

Because the facilitation effects remained the same size whereas the interference effects differed in size for the three tasks used, separate mechanisms that caused these effects should probably be hypothesised. The mechanism causing facilitation might be that in all tasks used, and relative to the control condition, an identical letter string facilitated the retrieval of the noun's phonology (or its lemma). The mechanism causing interference might involve other, and later, levels of processing. An unrelated letter string might hamper the retrieval of the noun's phonology (or its lemma), but, both in our article + noun naming task and our article naming task, it might also hamper the retrieval of the phonology of the article (as compared with the control condition). The presence of unrelated letters might even affect still later processes, for example at the response execution level (e.g., Posnansky & Rayner, 1978; Rayner & Posnansky, 1978). The important point is that an interference effect might be localised at more positions in the processing chain than a facilitation effect.

In terms of Caramazza's (1997) IN model, the equal phonological facilitation effects obtained for the three tasks used might thus be explained by the fact that, according to that model, in all tasks the noun's phonology had to be retrieved. The facilitation, then, reflected the faster retrieval of this phonological information when the picture was accompanied by its initial letters than when it was accompanied by *x*s. The interference effect might be explained somewhat differently. It is reasonable to assume that the activation level of the distractor representation is directly related to its ability to affect late stages of the naming process. Because the reduction of the interference effects obtained for the three tasks used (noun naming, article + noun naming, and article naming) was accompanied by a corresponding increase in overall reaction times for these tasks (714 ms, 767 ms, and 854 ms, respectively), the decreasing interference might reflect the decaying activation of the unrelated distractor representation.

Next we discuss whether the classical models might account for our results, especially those of Experiment 2. We will discuss serial models (e.g., Levelt et al., 1999a) and interactive models (e.g., Dell, 1986) in turn and also discuss the obtained phonological effect in the article + noun production task in some depth. We end with a discussion of an alternative interpretation of the results.

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Classical models and phonological facilitation in gender retrieval tasks

Classical models of language production might account for the reduction of the interference effects (defined as the difference between the unrelated condition and the control condition) obtained in the three tasks used in Experiment 2 in the same way as sketched above. That is, the reduction might be related to a decaying distractor representation, an aspect linked to language perception instead of production.

However, classical models seem to face difficulties in accounting for the (equal) phonological facilitation effects (defined as the difference between the control condition and the phonologically related condition) obtained for the three tasks used in Experiment 2. Strictly serial models of language production (e.g., Garrett, 1975; Butterworth, 1989; Levelt et al., 1999a) assume that there is no feedback from the phonological level back to the syntactic level of processing. That is, in these models the dotted arrow in Figure 1a is absent. Therefore, the basic finding that a phonological manipulation was able to influence gender retrieval processes (Experiments 1, 2, and 3) cannot easily be accounted for by these kinds of models. One possible route towards an explanation was taken by proponents of this type of model to account for Starreveld and La Heij's (1995, 1996b) interaction between semantic and phonological context effects in the picture–word task. This route is to assume that part of the phonological facilitation effect is localised at the syntactic level, but only when lemma retrieval is delayed as compared with a condition in which an unrelated word is used (Roelofs, Meyer, & Levelt, 1996; Levelt et al., 1999a, 1999b). The assumption is that a distractor, in these special circumstances, activates a cohort of orthographically related abstract word representations (lemmas) at the syntactic level. Here we will not go into the plausibility of this assumption (see Starreveld and La Heij, 1996a, 1999, and Levelt et al., 1999b, for discussion) but confine ourselves to pointing out that Levelt et al. (1999a) still assume that the lion's share of the phonological facilitation effect is localised at the phonological level. The implication is that any facilitatory effect of phonologically related distractors at the syntactic level will be small and that—consequently—the facilitatory effect on the selection of the gender node must be small. That is, the assumption that part of the phonological effect might be localised at the lemma level does not explain our observation in Experiment 2 that the phonological facilitation effects as defined as the difference between the related and control conditions did not differ significantly between the tasks used.

Interactive models assume that activation at the phonological level of processing feeds back to the syntactic (lemma) level. In Figure 1a this

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feedback is represented by a dotted arrow. Theoretically, this type of model could account for phonological effects in gender retrieval tasks in the following way. The increase in activation of the representation of the name of the picture at the phonological level due to the presentation of a phonologically related distractor feeds back to the lemma level and from there to the corresponding gender node. As a result, the selection of the correct lemma node and of the correct gender node will be facilitated, resulting in faster response latencies in tasks involving gender production or gender decision (relative to the situation in which an unrelated or control distractor is presented).

However, according to interactive models, the main part of the phonological effect in the noun naming task is still due to the faster retrieval of the noun's phonology. A much smaller part will be due to the faster retrieval of the noun's lemma as a result of feedback from the phonological level. Thus, in tasks involving gender retrieval, the selection of the corresponding lemma is facilitated but the amount of facilitation is small because only a small percentage of the extra activation that reaches the noun's phonological representation (due to the presentation of a phonologically related distractor) will reach the noun's lemma and gender nodes. As a result, interactive models also predict smaller phonological facilitation effects for tasks involving gender retrieval than for pure noun production tasks. It is with this prediction that these models face a similar difficulty as strictly serial models: The fact that only small amounts of additional activation due to the presence of a phonologically related distractor reach the syntactic level does not explain our observation in Experiment 2 that the phonological facilitation effects, defined as the difference between the related and control conditions, did not differ significantly between the tasks used.

In conclusion, classical models seem to have difficulties in accounting for the full pattern of the present results. These models might be modified in such a way that gender information is linked to phonological information, as in the model of Caramazza (1997). An alternative is not to modify the models themselves, but to change the standard interpretation of the phonological manipulation that we used. The standard interpretation is that this manipulation directly affects the phonological level only (see Starreveld, 2000, for a review). However, if it is assumed that this manipulation mainly affects the lemma level, the models fare much better. Indeed, based upon our results it seems necessary to assume that a considerable part of the phonological facilitation effect arises at the lemma level of word production.

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Phonological facilitation in the article + noun production task

Another aspect of our data deserves discussion. At first sight, the phonological facilitation effects obtained with the article + noun production task can be attributed to the facilitation of the retrieval of the noun. Although this attribution is indeed correct for the IN-model, it is probably not correct for the classical models of language production. As shown in Figure 1a, these latter models assume that the processes that are uniquely involved in the production of the article (like the retrieval of the gender node, the article's lemma, its phonological node and its segment nodes, we call these the *article-only* processes) and those that are uniquely involved in the production of the noun (like the retrieval of the noun's phonological node and its segments, the *noun-only* processes) diverge after the retrieval of the noun's lemma. It is reasonable to assume that these two types of processes run in parallel from the lemma level upwards (e.g., Meyer, 1996, states that 'if several lemmas [in this case those of the determiner and the noun] are selected more or less at the same time, several sets of form units are activated in parallel', p. 492). In fact, this assumption is necessary to account for the fact that several studies have reported shorter article + noun retrieval times than noun retrieval times (Costa & Caramazza, 2002; Jescheniak et al., 2003; Miozzo & Caramazza, 1999; Schriefers et al., 2002; see the discussion of Experiment 2). If it is true, however, that the article-only processes and the noun-only processes run in parallel, the faster of these types of processes cannot contribute to the overall reaction time (cf. critical pathway analysis, e.g., Schweikert, 1978).

Results from Experiment 2 (see Table 2) showed that the bare noun production task produced faster reaction times than the article + noun production task. These results thus indicate that the noun-only processes were faster than the article-only processes. As a consequence, the noun-only processes should not have contributed to the overall reaction times obtained in the article + noun production task.[2] Therefore, a manipulation that is assumed to speed up the noun-only processes, like our phonological manipulation, should not have affected overall reaction times in this task either. However, our phonological manipulation clearly did just that.

How then might the classical models account for the obtained phonological facilitation effects in the article + noun production task? Again, the standard interpretation of the phonological effect might be

[2] This reasoning is only valid if it is assumed that participants retrieved the complete phonology of both the article and the noun before they started the articulatory programming of the response (cf., critical pathway analysis, e.g., Schweikert, 1978). In our case, this is a reasonable assumption, given the required response and the fact that we obtained faster reaction times for noun naming than for article + noun naming.

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changed. Two options are apparent from Figure 1a: One is to assume that the slower of the two types of processes—the article-only processes—were actually facilitated, which is highly unlikely given the phonological manipulation that we used. The other option is to assume that the facilitation was located in that part of the processing chain that was shared by the production of the article and the noun. In the latter case, the most reasonable assumption seems to be that our phonological manipulation affected the retrieval of the noun's lemma. Note that the same conclusion was reached in the discussion of how the classical models might account for the phonological effects obtained in article naming tasks and gender decision tasks.

An alternative account of phonological facilitation in the article naming task and the gender decision task

According to the IN model (Caramazza, 1997), participants always retrieve the phonology of the noun when they are asked to produce the corresponding gender (see Figure 1b). In contrast, according to the classical models, retrieval of the noun's phonology is not necessary in order to produce the corresponding gender (see Figure 1a). However, it remains a possibility that in our article naming task, participants nevertheless always retrieved the complete article-noun phrase covertly, and then uttered only the article. Similarly, in the gender decision task participants might also have retrieved the complete article-noun phrase covertly, and have based their response upon mental inspection of the article. As a result, it seems that facilitation observed for article naming times and gender decision times could then be attributed to a facilitation of the covert retrieval of the noun's phonology.

However, besides being clearly post hoc, this alternative account introduces at least four, sometimes implicit, additional assumptions, which we discuss next. First, if participants covertly retrieved the complete article-noun phrase but uttered only the article, they somehow had to prevent the utterance of the noun. Second, although this might have occurred through an additional selection of the article from the fully retrieved article-noun phrase, a phonological effect cannot easily be explained that way (see our discussion of *phonological facilitation in the article + noun production task* above). Therefore, preventing the utterance of the noun should have been achieved through another mechanism, for example, through the inhibition of the noun's phonological representation. Third, this inhibition should not have had to await the retrieval of the full article-noun phrase, again because a phonological effect cannot easily be explained that way. And finally, although it might be argued that the faster

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a phonological representation is retrieved, the harder it will be to prevent it from being articulated, the duration of this inhibitory process should be independent of the retrieval time for the noun.

With respect to the article naming task, the present data only present support for the first of these assumptions. The finding of Experiment 2 that participants took more time to respond in the article naming task than in the article + noun naming tasks might be taken to indicate that participants in the article naming task somehow invoked additional processes to prevent the utterance of the noun. Because evidence for the other three assumptions is lacking, further research is necessary in order to investigate the merits of this alternative account. This recommendation concerns the gender decision task even more, because for this task empirical evidence for all four assumptions is presently lacking. In fact, Van Turennout et al. (1998) interpreted their results as clearly showing that gender decisions were made before the nouns' phonology was retrieved, disproving any covert noun naming account for this type of task.

Conclusions

We conclude that the pattern of results obtained in our three experiments follows quite naturally from Caramazza's (1997) IN model. Traditional production models that assume that gender information is retrieved via the noun's lemma have difficulties in accounting for the occurrence and/or the size of the phonological facilitation effects we obtained in the present study. Therefore, we think that Caramazza's (1997) IN model is a viable alternative for these traditional models in accounting for these effects.

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Appendix A

Stimulus materials used in Experiments 1 and 2

Pictures		*Distractors*					
Gender	*Name*	*Gen-Phon*	*Phon*	*Gen*	*Unrel*	*Phon*	*Unrel*
de	aap (monkey)	aardbei (strawberry)	aandeel (portion)	lezer	leger	aa	l
de	bal (ball)	band (tyre)	bad (bath)	vliet	vlies	b	vl
het	been (leg)	beest (beast)	beer (bear)	snoep	snoek	b	sn
het	dak (roof)	dal (valley)	dam (barrage)	beest	beer	d	b
het	graf (grave)	gras (grass)	grap (joke)	merk	melk	gr	m
de	hark (rake)	harp (harp)	hart (heart)	stem	stel	h	st
het	hek (fence)	heft (handle)	hel (hell)	raadsel	raaf	h	r
het	hert (deer)	hemd (vest)	held (hero)	zaad	zaag	h	z
het	kruis (cross)	kruid (herb)	kruik (jug)	schip	schim	kr	sch
het	lam (lamb)	land (land)	lat (slat)	kruid	kruik	l	kr
de	lepel (spoon)	lezer (reader)	leger (army)	zwaai	zwaard	l	zw
de	maan (moon)	maag (stomach)	maal (meal)	pap	pak	m	p
het	mes (knife)	merk (trademark)	melk (milk)	wier	wieg	m	w
de	pan (pan)	pap (porridge)	pak (suit)	zweer	zweet	p	zw
het	raam (window)	raadsel (riddle)	raaf (raven)	heft	hel	r	h
de	schaar (scissors)	schaal (dish)	schaap (sheep)	veeg	veen	sch	v
het	schild (shield)	schip (ship)	schim (shadow)	gras	grap	sch	gr
het	slot (lock)	slop (slum)	slok (draught)	dal	dam	sl	d
het	snoer (lead)	snoep (sweets)	snoek (pike)	hemd	held	sn	h
de	sok (sock)	som (sum)	sop (suds)	harp	hart	s	h
de	ster (star)	stem (voice)	stel (set)	vlam	vlak	st	vl
de	veer (spring)	veeg (wipe)	veen (peat)	schaal	schaap	v	ch
het	vest (waistcoat)	veld (field)	verf (paint)	land	lat	v	l
de	vlag (flag)	vlam (flame)	vlak (area)	som	sop	vl	s
de	vlieg (fly)	vliet (brook)	vlies (film)	band	bad	vl	b
de	voet (foot)	voetbal (soccer)	voedsel (food)	aardbei	aandeel	v	aa
het	wiel (wheel)	wier (seaweed)	wieg (cradle)	slop	slok	w	sl
het	zadel (saddle)	zaad (seed)	zaag (saw)	veld	verf	z	v
de	zwaan (swan)	zwaai (swing)	zwaard (sword)	voetbal	voedsel	zw	v
de	zweep (whip)	zweer (ulcer)	zweet (sweat)	maag	maal	zw	m

Note. Stimuli were presented in Dutch. English translations are given in parentheses. The control condition (not shown) consisted of a series of five lowercase *x*s in Experiment 1 and a series of two lowercase *x*s in Experiment 2. Gen-Phon = related in gender and phonology; Gen = related in gender only; Phon = related in phonology only; Unrel = Unrelated.

Appendix B

Stimulus materials used in Experiment 3

Pictures		*Distractors*	
Gender	*Name*	*Phon*	*Unrel*
de	ballon (balloon)	b	k
de	bank (bank)	b	l
het	bed (bed)	b	v
het	blad (leaf)	bl	sch
het	boek (book)	b	t
de	citroen (lemon)	c	m
de	gitaar (guitar)	g	k
het	glas (glass)	gl	st
de	kaars (candle)	k	p
de	kangoeroe (kangaroo)	k	b
het	kanon (canon)	k	s
het	kompas (compass)	k	b
het	konijn (rabbit)	k	g
de	liniaal (ruler)	l	k
de	mier (ant)	m	c
de	molen (mill)	m	sl
het	oor (ear)	oo	vl
het	paard (horse)	p	m
de	papegaai (parrot)	p	t
de	pet (cap)	p	v
het	potlood (pencil)	p	k
het	schilderij (painting)	sch	bl
de	sigaar (cigar)	s	k
de	slak (snail)	sl	p
het	stoplicht (traffic light)	st	gl
de	tang (tongs)	t	p
het	touw (rope)	t	b
het	varken (pig)	v	oo
het	vliegtuig (plane)	vl	b
de	vork (fork)	v	p

Note. Stimuli were presented in Dutch. English translations are given in parentheses. The control condition (not shown) consisted of a series of two lowercase *x*s. Phon = related in phonology; Unrel = unrelated.

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