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Context effects of pictures and words in naming objects, reading words, and generating simple phrases

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In five language production experiments it was examined which aspects of words are activated in memory by context pictures and words. Context pictures yielded Stroop-like and semantic effects on response times when participants generated gender-marked noun phrases in response to written words (Experiment 1A). However, pictures yielded no such effects when participants simply read aloud the noun phrases (Experiment 2). Moreover, pictures yielded a gender congruency effect in generating gender-marked noun phrases in response to the written words (Experiments 3A and 3B). These findings suggest that context pictures activate lemmas (i.e., representations of syntactic properties), which leads to effects only when lemmas are needed to generate a response (i.e., in Experiments 1A, 3A, and 3B, but not in Experiment 2). Context words yielded Stroop-like and semantic effects in picture naming (Experiment 1B). Moreover, words yielded Stroop-like but no semantic effects in reading nouns (Experiment 4) and in generating noun phrases (Experiment 5). These findings suggest that context words activate the lemmas and forms of their names, which leads to semantic effects when lemmas are required for responding (Experiment 1B) but not when only the forms are required (Experiment 4). WEAVER++ simulations of the results are presented.

An important issue in psychology concerns the extent to which processes are under voluntary control. For example, is the activation of names by perceived objects and words under voluntary control? In the early days of experimental psychology, Cattell (1886) reported that objects and colours took longer to name than the corresponding words took to read aloud. He held that "this is because, in case of words and letters, the association between the idea and name has taken place so often that the process has become automatic, whereas in the case of colours and pictures we must by a voluntary effort choose the name" (p. 65).

Cattell's distinction between automatic and voluntary processes has had a major influence on our thinking about psychological processes in general (MacLeod, 1991). However, his specific idea that objects and colours activate their names only when a speaker voluntarily wants to name them has received less attention. Moreover, modern psycholinguistic research has refined the

issue by distinguishing between several levels of mental representation for the names of objects. The WEAVER++ model represents names by concepts, lemmas (coding their syntactic properties), morphemes, speech segments, and motor programmes (Levelt, Roelofs, & Meyer, 1999). For example, the conceptually driven production of the word "catnap" in the model involves the activation of the representation of the concept CATNAP(X), the lemma of *catnap* specifying that the word is a noun (for languages such as Dutch, lemmas also specify grammatical gender), the morphemes <cat> and <nap>, the speech segments/k/,/æ/,/t/,/n/, and/p/, and the syllable motor programmes [kæt] and [næp]. The issue, then, has become which of the several representations of an object name are activated in a voluntary fashion by perceived objects and written words.

Levelt et al. (1999) argued that perceived objects activate concepts and lemmas regardless of a speaker's intention, whereas the morphemes, segments, and motor programmes of the object names are only activated when a speaker intends to name the objects. That is, the task of object naming enables the link between lemmas and forms to be made (cf. Monsell, 1996). Other researchers argued that all word forms corresponding to the activated concepts and lemmas become activated regardless of the intention (Dell, 1986). More recently, Altmann and Davidson (2001) and Bloem and La Heij (2003; Bloem, Van den Bogaard, & La Heij, 2004) argued that although objects activate their concepts and related ones, the lemmas, morphemes, segments, and motor programmes of the object names are only activated when a speaker wants to name the objects.

Altmann and Davidson (2001) and Bloem and La Heij (2003) argued for their position on the basis of the classic colour–word Stroop asymmetry (MacLeod, 1991; Stroop, 1935). Speakers are slower in naming the ink colour of incongruent colour words (e.g., say "red" to the word BLUE in red ink) than that of a coloured series of Xs. Furthermore, they are faster than control (e.g., XXXX in red ink) when colour and colour word agree in the congruent condition (e.g., the word

RED in red ink). Henceforth, the difference in performance between incongruent and congruent stimuli is called the Stroop effect. When the task is to read aloud the words and to ignore the ink colours there is no effect. The difference in effect of word distractors in colour naming and colour distractors in word reading is called the Stroop asymmetry. To explain the asymmetry, Altmann and Davidson (2001) held that "color distractors have no effect because color stimuli are not processed ballistically, as words are. In response to a color stimulus, the system does not automatically activate a lemma" (p. 24). Similarly, Bloem and La Heij (2003) assumed that "nonverbal contextual stimuli (e.g., colors) are processed up to the level of identification but do not activate their names" (p. 476).

Bloem and La Heij (2003) also argued for their position on the basis of a "semantic relatedness paradox". In naming pictured objects, semantic interference is obtained from word distractors (e.g., Glaser & Düngelhoff, 1984). For example, naming a pictured dog is slowed down by the distractor word CAT (semantically related; i.e., *dog* and *cat* are both members of the animal category) compared to the word TREE (semantically unrelated). However, picture distractors yield semantic facilitation in conceptually driven responding to words. For example, producing the hyperonym "animal" in response to the word DOG is faster when the word is superimposed onto a pictured cat than when it is on a pictured tree. In their own research, Bloem and La Heij (2003) observed that a written English word is translated faster into Dutch (e.g., saying Dutch "hond" in response to English DOG) by Dutch–English bilingual speakers when the English word is superimposed onto a pictured cat (semantically related) than when it is on a pictured tree (semantically unrelated). In contrast, translating the word DOG is slower when the Dutch distractor word KAT (CAT, semantically related) is presented than when the Dutch word BOOM (TREE, semantically unrelated) is presented. Thus, the direction of the semantic effect differs between distractor pictures and words. The difference in effect suggests that "context pictures activate their

conceptual representations, but do not automatically activate their names" (Bloem & La Heij, 2003, p. 476). Consequently, distractor pictures help concept selection in a translation task but they do not lead to competition in selecting the target word, yielding semantic facilitation. In contrast, because distractor words automatically activate the corresponding names, they compete in naming pictures and translating words, yielding semantic interference.

According to Bloem and La Heij (2003), models of word production such as WEAVER++ "are able to account for semantic interference induced by a context word, but not for semantic facilitation induced by a context picture" (p. 477). However, WEAVER++ has simulated both the semantic interference from distractor words in picture naming and the semantic facilitation from distractor pictures in conceptually driven responding to words (e.g., Levelt et al., 1999; Roelofs, 1992, 2003). Moreover, Roelofs (2003) reported findings that supported WEAVER++ and that challenge the position of Bloem and La Heij (2003; Bloem et al., 2004). If perceived objects activate the lemmas of their names regardless of whether a speaker wants to name them, the concept selection in word categorizing and translating is not critical for the semantic facilitation effect from pictures. The effect should also be obtained when only lemma level information, such as a word's grammatical gender, needs to be selected. This prediction was tested in an experiment that exploited the linguistic fact that nouns take gender-marked articles in Dutch definite noun phrases, namely "het" with neuter gender and "de" with nonneuter gender. When a noun is presented, and participants have to read aloud the noun while preceding the noun by its gender-marked article (not visually presented), the grammatical gender of the noun needs to be retrieved to determine the right article, "de" or "het". For example, if participants have to respond to the word HOND (dog) by saying "de hond", the gender of the noun *hond* needs to be accessed to determine the correct determiner, "de". Consequently, when distractor pictures activate the lemmas of their names, semantic facilitation is predicted, and this was

indeed empirically obtained. The pictures had no effect when the words were simply read aloud without the article.

According to WEAVER++, naming an object involves object-form perception, conceptual identification, lemma retrieval, word-form encoding, and articulation (see Figure 1). The model distinguishes between automatic spreading of activation in a lexical network and the actual selection of nodes. Perceived objects automatically activate the lemmas of their names in the network, but the actual selection of lemmas and the encoding of word forms depends on the task. For example, lemmas are selected for target pictures, but not in response to distractor pictures. Perceived words automatically activate both lemmas and word forms in the lexical network. Whether the activated lemmas and forms are actually selected depends, again, on the task. Whereas noun phrase generation in response to a perceived word requires lemma selection (Route A in Figure 1), reading words aloud can be accomplished by form selection only (Route B). Consequently, distractor pictures affect word reading only when the lemma level is required, which is the case with noun phrase generation in response to a written word (Route A) but not with bare word reading (Route B).
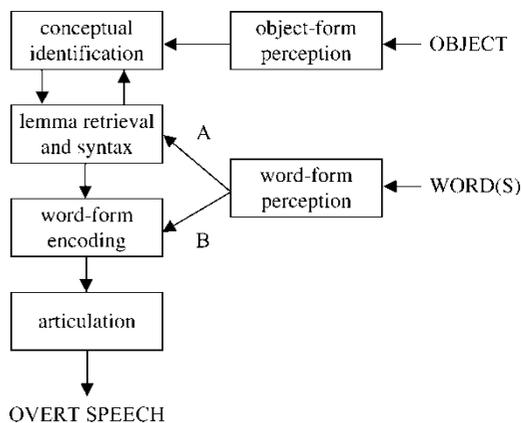
Figure 1. *Functional architecture for naming objects, reading their names, and reading and generating noun phrases assumed by the WEAVER++ model (Roelofs, 1992, 2003). Oral reading may involve lemma selection (Route A) or may not (Route B).*

Computer simulations showed that WEAVER++ explains why semantic interference is obtained from words in picture naming, and why semantic facilitation is obtained from pictures in responding to words that requires lemma access (Roelofs, 2003). Word distractors in picture naming yield longer latencies in the semantic than in the unrelated condition in WEAVER++ , because the target picture activates the lemma of a semantically related distractor word more than the distractor word activates the target lemma, due to distances in the model's lexical network. In reversing the target–distractor relation by making the word the target and the picture the distractor, the network distances and the resulting direction of the semantic effect also reverses: Semantic interference turns into semantic facilitation.

OVERVIEW OF THE EXPERIMENTS

The aim of the present experiments was to test between the different views on which aspects of lexical representations are voluntarily activated by objects and words. The objective of Experiments 1A and 1B was to replicate the semantic related-ness paradox using tasks that do not involve translation between languages (the task used by Bloem & La Heij, 2003). In Experiment 1A, participants had to generate Dutch gender-marked noun phrases in response to written words (requiring Route A in Figure 1) while simultaneously trying to ignore distractor pictures. For example, they had to say "de hond" in response to the word HOND (dog), while trying to ignore a pictured cat (semantic), a pictured tree (unrelated), a pictured dog (identical), or an empty rectangle (control). The experiment tested for semantic facilitation (semantic vs. unrelated) and Stroop-like effects (semantic vs. identical). Experiment 1B tested for the semantic-interference half of the semantic relatedness paradox. If distractor words activate their concept, lemma, and form representations, they should yield Stroop-like and semantic-interference effects in naming pictures.

In Experiment 2, the noun phrases of Experiment 1A were presented in full on the computer screen. Participants simply had to read aloud the gender-marked noun phrases (which can be accomplished via Route B in Figure 1) while simultaneously trying to ignore the distractor pictures. For example, they had to say "de hond" in response to DE HOND (the dog), while trying to ignore a pictured cat (semantic), a pictured tree (unrelated), a pictured dog (identical), or an empty rectangle (control). If irrelevant objects activate the corresponding lemmas but not the forms, distractor pictures should yield Stroop-like effects and semantic facilitation effects in generating gender-marked noun phrases in response to written words (because phrase generation requires Route A) but not in simply reading the noun phrases (because Route B suffices for reading). In contrast, if the activation of lemmas by objects is under voluntary control, distractor pictures should have no effect at all in both generating and reading.

Schriefers (1993) observed a gender congruency effect of written distractor words in naming pictures by gender-marked noun phrases (see also La Heij, Mak, Sander, & Willboordse, 1998). For example, participants said "de hond" in response to a pictured dog, while trying to ignore the distractor word OOR (ear, a "het" word, the gender-incongruent condition) or the word BOOM (tree, a "de" word, the gender-congruent condition). Experiments 3A and 3B tested for gender congruency effects from distractor pictures in generating gender-marked noun phrases in response to written words (requiring Route A in Figure 1). For example, participants said "de hond" in response to the word HOND (dog), while trying to ignore a pictured ear (gender incongruent), a pictured tree (gender congruent), or an empty rectangle (control). If objects activate the corresponding words up to their lemmas regardless of a speaker's intention, the distractor pictures should yield a gender congruency effect. In contrast, if the activation of lemmas by objects is under voluntary control, distractor pictures should have no effect at all.

If only selected lemmas activate the corresponding word forms, and word reading can be

achieved without lemma selection (via Route B in Figure 1), word distractors should yield Stroop-like but not semantic effects in word reading. This was tested in Experiment 4.

Several models assume that grammatical gender is lexically available from lemmas (Levelt et al., 1999; Roelofs, 1992) or phonological forms (Caramazza, 1997). However, other researchers suggested that gender may be assigned to nouns according to semantic factors (Corbett, 1991; Schwichtenberg & Schiller, 2004). If grammatical gender assignment requires concept selection in actual language production, Stroop-like and semantic effects in noun phrase generation would be compatible with the position of Altmann and Davidson (2001) and Bloem and La Heij (2003; Bloem et al., 2004). This is because, in their view, context pictures may affect concept selection without activating the picture names. Experiment 5 tested whether grammatical gender is available at the conceptual level. Participants had to generate gender-marked noun phrases in response to written nouns while trying to ignore written distractor words. If grammatical gender is available from concepts, and noun phrase generation requires concept selection, just like picture naming, the distractor words should yield Stroop-like and semantic interference effects (as tested in Experiment 1B). However, if grammatical gender is stored lexically, the distractor words should yield a Stroop-like but not a semantic effect (in word–word tasks, the network distance from target to distractor and vice versa is the same in WEAVER++).

Whereas semantic effects and gender congruency effects of words in picture naming occur with simultaneous presentation of picture and word (semantic effects: Glaser & Düngelhoff, 1984; gender congruency effects: Schriefers, 1993), WEAVER++ predicts that gender congruency effects of pictures on words occur with preexposed pictures. In the model, words have direct access to the level that represents gender (the lemma level), whereas pictures have only indirect access to that level, namely via the conceptual level (see Figure 1). Consequently, picture distractors should be given a head start to obtain

a gender congruency effect in responding to words. Given that the different effects vary in their timing, the stimulus onset asynchrony (SOA) between target and distractor was explicitly manipulated in the experiments. The onset of the presentation of the distractors was 150 ms before target onset (henceforth called *distractor-first* SOAs, indicated by a minus sign), distractor and target were presented simultaneously (i.e., SOA = 0 ms), or the onset of the presentation of the distractors was 150 ms after target onset (*distractor-second* SOAs).

EXPERIMENT 1A

Experiment 1A tested for Stroop-like and semantic effects from distractor pictures in generating gender-marked noun phrases in response to written words. If objects activate the corresponding words up to their lemmas regardless of whether a speaker wants to name them, the distractor pictures should yield Stroop-like and semantic facilitation effects. In contrast, if the activation of lemmas by objects is under voluntary control, there should be no effect.

Method

Participants
Each experiment was carried out with a different group of 12 paid participants from the pool of the Max Planck Institute. All participants were young adults, who were native speakers of Dutch. None of them took part in more than one experiment.

Materials and design
From the picture gallery available at the Max Planck Institute, 32 pictured objects from eight different semantic categories were selected, together with their basic-level names in Dutch. Two of the objects in a category had names with neuter grammatical gender (the *het* words), and the two remaining objects had names with non-neuter gender (the *de* words). The Appendix lists the materials. In addition to the 32 pictured

objects, a drawing of an empty picture frame was created to serve as a neutral control picture. Furthermore, four additional pictures from two semantic categories (different from the eight experimental categories) were selected as practice items. The pictures were white line drawing on a black background. They were digitized and scaled to fit into a virtual frame of 10 cm × 10 cm. The words were presented in 36-point lowercase Arial font.

There were two independent variables, both varied within participants. The first independent variable was distractor. Each target word was combined with the corresponding picture (identical), with a picture from the same semantic category (semantic), with a picture from another semantic category (unrelated), or with the neutral picture frame (control). The Appendix gives the pairings. The word and the picture name always had the same grammatical gender. A participant received 32 word–picture pairings in each of the four distractor conditions, yielding 128 picture–word stimuli in total. The stimuli were presented in random order. The second independent variable was SOA. The distractor effects were assessed at different SOAs: −150 ms, distractor preexposure; 0 ms; or 150 ms, distractor postexposure. All 128 picture–word stimuli were tested at each SOA. Trials were blocked by SOA. The order of testing SOAs was fully counterbalanced across participants.

Procedure and apparatus

The participants were tested individually. They were seated in front of a computer monitor (NEC Multisync) and a Sennheiser microphone connected to an electronic voice key. The distance between participant and screen was approximately 50 cm. Before the beginning of the experiment, the participants were familiarized with the words and the pictures. The participants were instructed to respond to the words by generating determiner-noun phrases, while trying to ignore the distractor pictures. After a participant had read the instructions, a block of 12 practice trials was administered, which was followed by the experimental SOA blocks of trials. The structure of a trial was

as follows. First, the participant saw an asterisk for 0.5 s. Next, the screen was cleared for 0.5 s, followed by the display of the distractor picture and the target word with the appropriate SOA. Picture and word disappeared from the screen 1.5 s after word presentation onset. The asterisk, picture, and word were presented in white on a black background. The target words appeared in the middle of the screen, and the distractor pictures were centred around the words. Before the start of the next trial there was a blank interval of 0.5 s. Thus, the total duration of a trial was 3.0 s. A Hermac computer controlled the presentation of the stimuli and the collection of response times.

Analysis. After each trial, the experimenter coded the response for errors. Five types of incorrect response were distinguished: wrong response word, wrong pronunciation of the word, a disfluency, triggering of the voice key by a non-speech sound, and failure to respond within 1.5 s after target presentation. Incorrect responses were excluded from the statistical analyses of the response latencies. The latencies and errors were submitted to by-participant (F_1) and by-item (F_2) analyses of variance with the crossed variables distractor and SOA. Interactions of distractor and SOA were further statistically explored through paired t tests carried out both by participants and by items. To test for semantic effects, the latencies and errors in the semantic and unrelated conditions were compared. To test for Stroop-like effects, the latencies and errors in the semantic and identical conditions were compared. An alpha level of .05 was adopted in all comparisons.

Results and discussion

Table 1 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 2 shows the effects of the semantic, unrelated, and identical distractors relative to the control condition. The statistical analysis of the latencies yielded a main effect of distractor, $F_1(3, 33) = 18.52$, $MSE = 256$, $p < .001$, $F_2(3, 93) = 17.81$, $MSE = 710$, $p < .001$. There was an SOA effect

Table 1. *Mean response latencies[a] and error percentages per distractor and SOA for Experiment 1A*

	SOA											
	−150			0			150			Total		
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Semantic	548	117	5.0	550	107	3.9	553	112	2.6	550	112	3.8
Unrelated	562	130	3.4	574	121	3.9	558	110	2.6	565	121	3.3
Identical	516	96	3.4	549	110	3.4	555	113	2.6	540	108	3.1
Control	534	96	2.3	540	107	1.6	545	102	2.9	540	102	2.3

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.

by items but not by participants, $F_1(2, 22) < 1$, $F_2(2, 62) = 11.47$, $MSE = 684$, $p < .001$. The effect of distractor varied with SOA, $F_1(6, 66) = 3.75$, $MSE = 299$, $p < .003$, $F_2(6, 186) = 4.74$, $MSE = 685$, $p < .001$. Pairwise comparisons showed that the response latencies were shorter in the semantic condition than in the unrelated condition at the SOAs of −150 ms ($ps < .04$) and 0 ms ($ps < .001$), but not at SOA = 150 ms ($ps > .40$). Moreover, the response latencies were shorter in the identical condition than in the semantic condition at the SOA of −150 ms

Figure 2. *Latency effects for generating gender-marked noun phrases in response to written words in the context of picture distractors in Experiment 1A. Depicted are the effects of semantic, unrelated, and identical distractors relative to control.*

($ps < .005$), but not at the later SOAs ($ps > .70$). The analysis of the errors yielded no significant results.

Roelofs (2003) obtained a semantic facilitation effect at SOA = −150 ms, which was replicated in the present study. Moreover, a semantic facilitation effect was obtained at SOA = 0 ms (this SOA was not tested in Roelofs, 2003). In addition, a Stroop-like effect (shorter latencies in the identical than in the semantic condition) was obtained in the present study (not tested in Roelofs, 2003). These effects of picture distractors suggest that pictured objects activate the lemmas of their names regardless of whether a speaker wants to name them.

EXPERIMENT 1B

In Experiment 1A, distractor pictures yielded semantic facilitation in responding to written words. Experiment 1B was a picture–word interference experiment that tested for the other half of the semantic relatedness paradox, namely semantic interference from distractor words in picture naming.

Method

This was the same as that in Experiment 1A, except that now the pictures were named, and the words were ignored. The control condition consisted of five Xs in 36-point Arial font.

Results and discussion

Table 2 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 3 shows the effects of the semantic, unrelated, and identical distractors relative to the control condition. The statistical analysis of the latencies yielded a main effect of distractor, $F_1(3, 33) = 60.07$, $MSE = 1,064$, $p < .001$, $F_2(3, 93) = 56.52$, $MSE = 3,080$, $p < .001$, but not of SOA, $F_1(2, 22) = 1.75$, $MSE = 5,054$, $p > .20$, $F_2(2, 62) = 15.16$, $MSE = 1,559$, $p < .001$. The effect of distractor varied with SOA, $F_1(6, 66) = 7.57$, $MSE = 835$, $p < .001$, $F_2(6, 186) = 11.08$, $MSE = 1,565$, $p < .001$. Pairwise comparisons showed that the response latencies were longer in the semantic condition than in the unrelated condition at SOA $= 0$ ms (ps $< .02$), but not at the other SOAs (ps $> .13$). The latencies in the identical condition differed from those in the semantic condition at all three SOAs (ps $< .001$). The statistical analysis of the error rates yielded only a significant result for distractor, $F_1(3, 33) = 16.47$, $p < .001$, $F_2(3, 93) = 7.43$, $p < .001$. Comparisons showed that more errors were made in the semantic than in the unrelated condition (ps $< .002$). Thus, most errors were made in the slowest condition, which suggests that there was no speed–accuracy trade-off.

To conclude, context pictures yielded semantic facilitation (Experiment 1A), and context words yielded semantic interference (Experiment 1B).

Thus, the semantic relatedness paradox is also observed with noun phrase generation in response to words and picture naming. Contrary to what is assumed by Bloem and La Heij (2003), concept selection is not required in order to obtain the semantic facilitation of context pictures.

EXPERIMENT 2

If the semantic effects of Experiment 1A arose because of lemma retrieval, the effects should disappear when the noun phrases are read either through the application of grapheme–phoneme correspondence rules or through a mapping involving morphemes (both involving Route B in Figure 1). Moreover, the pictures should not yield a Stroop-like effect. These predictions were tested in Experiment 2.

Method

This was the same as that in Experiment 1A, except that the noun phrases were presented on the screen in full, and participants simply read them aloud.

Results and discussion

Table 3 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 4

Table 2. *Mean response latencies*[a] *and error percentages per distractor and SOA for Experiment 1B*

| | SOA | | | | | | | | | | | |
| | −150 | | | 0 | | | 150 | | | Total | | |
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Semantic	760	149	3.7	812	178	4.7	824	194	6.3	798	177	4.9
Unrelated	751	160	3.1	779	139	1.0	806	188	1.3	779	165	1.8
Identical	701	139	2.3	727	160	1.0	696	151	2.1	708	151	1.8
Control	741	149	1.8	729	152	1.6	721	161	1.6	730	154	1.7

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.
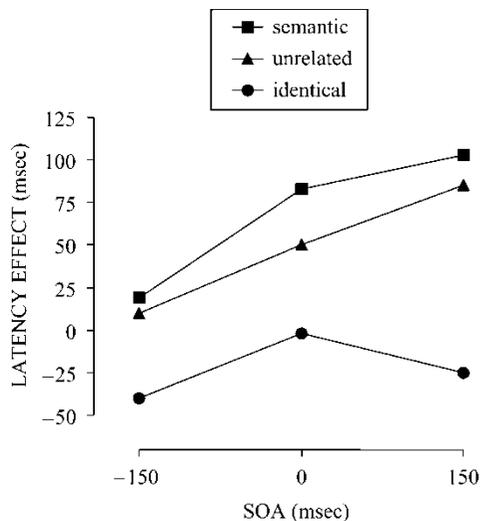
Figure 3. *Latency effects for naming pictures in the context of word distractors in Experiment 1B. Depicted are the effects of semantic, unrelated, and identical distractors relative to control.*

shows the effects of the semantic, unrelated, and identical distractors relative to the control condition. The statistical analysis of the latencies yielded no reliable effect of distractor, $F_1(3, 33) = 2.58$, $MSE = 208$, $p > .07$, $F_2(3, 93) = 3.22$, $MSE = 445$, $p < .03$. The effect of SOA was significant by items only, $F_1(2, 22) = 2.48$, $MSE = 3,202$, $p > .11$, $F_2(2, 62) = 42.82$, $MSE = 499$, $p < .001$. There was no interaction of distractor and SOA, $F_1(6, 66) = 1.81$, $MSE = 191$, $p > .11$, $F_2(6, 186) = 2.23$, $MSE = 420$, $p < .04$. Pairwise comparisons revealed that there was no

semantic effect (i.e., no difference in effect between semantically related and unrelated distractors) at any SOA ($ps > .33$). There was also no difference between the identical and semantic conditions at any SOA ($ps > .10$). The statistical analysis of the error rates yielded no significant results. Thus, although there was a marginal effect of distractor on the response latencies, the important pairwise comparisons were not significant. This supports the conclusion that the distractor pictures yielded no semantic and Stroop-like effects.

To conclude, the effects observed in Experiment 1A were not present when the noun phrases were simply read aloud rather than being generated from a written noun. This suggests that the effects in Experiment 1A occurred because of lemma retrieval.

EXPERIMENT 3A

Schriefers (1993) observed a gender congruency effect of written distractor words in naming pictures by gender-marked noun phrases. Experiment 3A tested for a gender congruency effect from distractor pictures in generating gender-marked noun phrases in response to written words. For example, participants said "de hond" in response to the word HOND (dog), while trying to ignore a pictured ear (gender incongruent), a pictured tree (gender congruent), or an empty rectangle (control). If objects activate

Table 3. *Mean response latencies[a] and error percentages per distractor and SOA for Experiment 2*

| | SOA | | | | | | | | | | | |
| | −150 | | | 0 | | | 150 | | | Total | | |
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Semantic	468	84	4.7	496	92	2.1	485	82	5.2	483	87	4.0
Unrelated	473	75	5.5	501	91	4.2	485	78	5.0	486	82	4.9
Identical	460	66	3.9	490	83	2.6	483	79	4.7	478	77	3.7
Control	469	62	4.2	483	78	3.7	488	79	5.2	480	74	4.3

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.
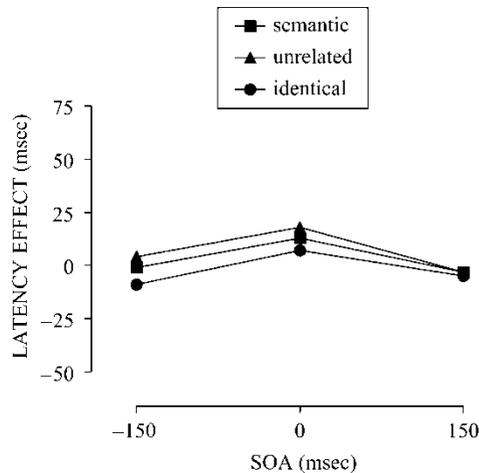
Figure 4. *Latency effects for reading of gender-marked noun phrases in the context of picture distractors in Experiment 2. Depicted are the effects of semantic, unrelated, and identical distractors relative to control.*

the corresponding words up to their lemmas regardless of whether a speaker wants to name them, the distractor pictures should yield a gender congruency effect. In contrast, if the activation of lemmas by objects is under voluntary control, distractor pictures should have no effect at all.

Method

This was the same as that in Experiment 1A, except that the words and pictures were recombined into

gender-congruent and gender-incongruent combinations. The unrelated distractor pictures for each semantic category (see the Appendix) were recombined with the words such that each word was combined with the two gender-incongruent semantically unrelated pictures, the two gender-congruent semantically unrelated pictures, and the control picture frame, yielding 160 word–picture stimuli in total. Each stimulus pair was tested once in each SOA block. The stimuli were presented in random order.

Results and discussion

Table 4 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 5 shows the effects of the gender-congruent and gender-incongruent distractors relative to the control condition. The statistical analysis of the latencies yielded an effect of distractor, $F_1(2, 22) = 22.79$, $MSE = 150$, $p < .001$, $F_2(2, 62) = 23.28$, $MSE = 390$, $p < .001$, but not of SOA, $F_1(2, 22) < 1$, $MSE = 1,746$, $p > .72$, $F_2(2, 62) = 3.24$, $MSE = 501$, $p < .05$. There was an interaction of distractor and SOA, $F_1(4, 44) = 5.77$, $MSE = 113$, $p < .001$, $F_2(4, 124) = 4.63$, $MSE = 389$, $p < .002$. Pairwise comparisons showed that the gender congruency effect of 10 ms at SOA = -150 ms was significant, $t_1(11) = 3.2$, $p < .005$, $t_2(31) = 2.1$, $p < .03$. There were no effects at the other SOAs (ps $> .80$). The statistical analysis of the error rates yielded no significant results.

Table 4. *Mean response latencies[a] and error percentages per distractor and SOA for Experiment 3A*

	SOA											
	−150			0			150			Total		
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Gender incongruent	575	98	2.6	561	100	3.1	553	103	3.8	563	101	3.2
Gender congruent	565	100	2.1	562	97	1.8	555	102	2.3	560	100	2.1
Control	541	80	1.8	545	91	4.4	548	95	3.1	545	89	3.1

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.
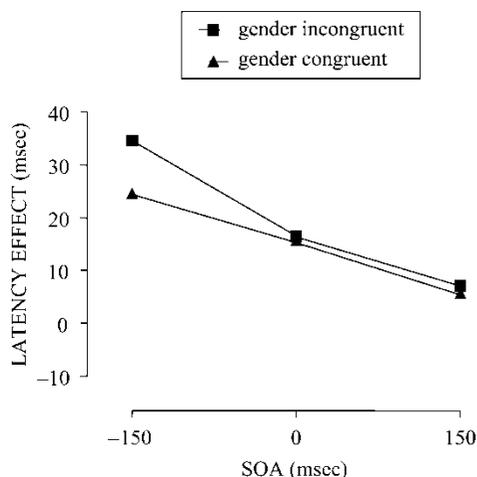
Figure 5. *Latency effects for generating gender-marked noun phrases in response to written words in the context of picture distractors in Experiment 3A. Depicted are the effects of gender-incongruent and gender-congruent distractors relative to control.*

The results show that distractor pictures yielded a gender congruency effect in generating gender-marked noun phrases in response to written words. This suggests that objects activate the corresponding words up to their lemmas regardless of whether a speaker wants to name them. The results also demonstrate the importance of the SOA manipulation. If the SOA had not been manipulated (i.e., if only SOA = 0 ms had been used), no gender congruency effect would have been obtained. Whereas gender congruency effects of distractor words in picture naming occur at SOA = 0 ms (Schriefers, 1993), the gender effect of pictures on words occurred at the SOA of −150 ms. This difference in timing is expected when words have direct access to the level that represents gender (the lemma level), whereas pictures have only indirect access to that level, namely via the conceptual level (see Figure 1). Consequently, picture distractors should be given a head start to obtain a gender congruency effect in responding to words, as observed.

The semantic facilitation effect in Experiment 1A occurred at the SOAs of −150 and 0 ms, whereas the gender congruency effect was obtained only at SOA = −150 ms. Such a difference in the timing of semantic and gender effects may happen when lemma selection (yielding the semantic effect) and gender selection (yielding the gender effect) are separate operations, as in WEAVER++ (see Levelt et al., 1999). In WEAVER++, a gender node is selected for a selected lemma node, and thus gender selection necessarily follows lemma selection. The different timing of the semantic and gender effects challenges the view that gender information becomes automatically available as part of selecting a lemma (Caramazza, Miozzo, Costa, Schiller, & Alario, 2001).

EXPERIMENT 3B

When the picture distractor is presented first (at SOA = −150 ms) in noun phrase generation, participants may have the tendency to covertly name the picture with a noun phrase or prepare the corresponding determiner. Such a strategy may lead to competition in the gender incongruent case or facilitation in the congruent case (cf. Schiller & Caramazza, 2003). This strategy would not be possible at the SOAs of 0 and 150 ms, accounting for the absence of the effect at these SOAs in Experiment 3A.

A problem with this alternative account of the data is that such a strategy would predict effects of picture distractors on word reading. When participants covertly name preexposed pictures with a noun phrase or prepare the determiner, they can also be expected to covertly name the pictures using single nouns. However, picture distractors did not affect word reading in Experiment 2. A difference between Experiment 2 and Experiment 3A, however, is the proportion of congruent trials. In Experiment 2, the pictures had the same name as the target word on one third of the trials. In Experiment 3A, the determiner of the picture name was the same as that of the target word on half the trials. Thus, it may be that the participants refrained from preparing the picture distractor's name in Experiment 2,

because the proportion of congruent trials was simply too low to make it useful. Experiment 3B tested this possibility by making the proportion of congruent trials equal to the proportion in Experiment 2. If the proportion account is correct, this should eliminate the gender congruency effect.

Method

This was the same as that in Experiment 3A, except that the number of gender-incongruent trials was doubled. Now, on only one third of the trials, the picture names had the same gender as that of the target words. Only the SOA of −150 ms was tested.

Results and discussion

The mean response latencies for the gender-incongruent, gender-congruent, and control conditions were 611, 602, and 574 ms, respectively. The standard deviations were 125, 120, and 110, respectively, and the error percentages were 1.3, 1.9, and 1.0. The statistical analysis of the latencies yielded an effect of distractor, $F_1(2, 22) = 23.41$, $MSE = 196$, $p < .001$, $F_2(2, 62) = 19.25$, $MSE = 597$, $p < .001$. Pairwise comparisons showed that the gender congruency effect of 9 ms was significant, $t_1(11) = 2.1$, $p < .03$, $t_2(31) = 1.7$, $p < .05$. Thus, the gender congruency effect of Experiment 3A is replicated.

To conclude, a gender congruency effect is obtained even when the picture and word have the same gender on only one third of the trials. In Experiment 2, distractor pictures did not affect noun phrase reading, whereas pictures did affect noun phrase generation in the present experiment. The proportion of related trials was the same in the experiments. These results suggest that distractor pictures activate the lemmas of their names regardless of a speaker's intention. The lemma activation leads to effects when lemmas are needed to generate a response (Experiments 3A and 3B), but not when the response can be achieved without lemma selection (Experiment 2).

EXPERIMENT 4

If word reading can be achieved without lemma selection (via the direct route from word-form perception to word-form encoding, Route B in Figure 1), and only selected lemmas activate the corresponding word forms, word distractors should yield a Stroop-like but not a semantic effect in word reading, as observed by Glaser and Glaser (1989). In their experiment, the target and distractor words were presented with a certain SOA, and participants named the first or second word that appeared on the screen. Bloem and La Heij (2003) criticized the temporal discrimination (i.e., the target is determined on the basis of the SOA) in this task by arguing that it imposes special selection difficulties. Furthermore, only nine different words from three semantic domains were used. Thus, it is important to examine whether the results of Glaser and Glaser (1989) can be replicated without the temporal discrimination task and a larger stimulus set. This was done in Experiment 4.

Method

This was the same as that in Experiment 1B, except that now written words were read aloud while distractor words were ignored. The written target words corresponded to the picture names of Experiment 1B (see the Appendix). The words appeared next to each other in the centre of the computer screen. The target words were underlined. The left–right position of the target words varied randomly from trial to trial.

Results and discussion

Table 5 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 6 shows the effects of the semantic, unrelated, and identical distractors relative to the control condition. The statistical analysis of the latencies yielded a main effect of distractor, $F_1(3, 33) = 54.86$, $MSE = 343$, $p < .001$, $F_2(3, 93) = 85.46$,

Table 5. *Mean response latencies[a] and error percentages per distractor and SOA for Experiment 4*

	SOA									Total		
	−150			0			150					
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Semantic	592	87	1.3	632	93	1.6	542	90	1.0	589	97	1.3
Unrelated	599	104	2.9	627	93	2.6	548	107	1.3	591	107	2.3
Identical	534	102	3.1	562	90	0.8	542	104	1.0	546	99	1.7
Control	560	87	1.8	560	79	0.3	549	93	1.6	556	86	1.2

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.

$MSE = 581$, $p < .001$, and of SOA, $F_1(2, 22) = 18.50$, $MSE = 1,653$, $p < .001$, $F_2(2, 62) = 138.25$, $MSE = 592$, $p < .001$. The effect of distractor varied with SOA, $F_1(6, 66) = 14.22$, $MSE = 394$, $p < .001$, $F_2(6, 186) = 23.37$, $MSE = 639$, $p < .001$. Pairwise comparisons showed that the response latencies in the semantic condition and in the unrelated condition did not differ at any SOA ($ps > .25$). Moreover, the latencies in the identical condition differed from those in the semantic condition at the SOAs of −150 and 0 ms ($ps < .001$), but not at

SOA = 150 ms ($ps > .90$). The statistical analysis of the errors yielded no significant results.

To conclude, whereas written word distractors yielded Stroop-like and semantic interference effects in picture naming (Experiment 1B), the same word distractors yielded a Stroop-like but not a semantic effect when the picture names were presented as written words and the participants had to read them aloud. These findings replicate Glaser and Glaser (1989) without a temporal discrimination task and with a much larger set of materials. The absence of a semantic effect suggests that word reading can be achieved via a form-to-form mapping (Route B in Figure 1) without selecting a lemma (Roelofs, 1992, 2003).
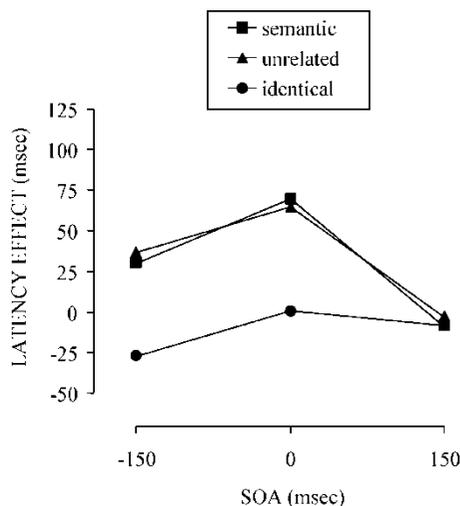
Figure 6. *Latency effects for reading words in the context of word distractors in Experiment 4. Depicted are the effects of semantic, unrelated, and identical distractors relative to control.*

EXPERIMENT 5

If grammatical gender is derived from concepts, the observed Stroop-like and semantic effects in noun phrase generation (Experiment 1A) are compatible with the position of Altmann and Davidson (2001) and Bloem and La Heij (2003; Bloem et al., 2004). According to these researchers, context pictures may influence concept selection without activating picture names. Experiment 5 examined whether grammatical gender is lexically or conceptually available. Participants generated gender-marked noun phrases in response to written words while trying to ignore distractor words. If grammatical gender is available at the conceptual level, and noun

phrase generation requires concept selection, just like picture naming, the distractor words should yield Stroop-like and semantic effects, just as they did with picture naming in Experiment 1B. Also, Bloem and La Heij (2003) obtained semantic interference of distractor words when participants translated words from their second to their first language, suggesting a conceptual involvement in the translation process. In contrast, if grammatical gender is stored lexically, the distractor words should yield a Stroop-like but not a semantic effect in generating gender-marked noun phrases in response to written words.

Method

This was the same as that in Experiment 4, except that now gender-marked noun phrases were generated in response to the written words. The words appeared next to each other on the computer screen. The target words were underlined. The left–right position of the target words varied randomly from trial to trial.

Results and discussion

Table 6 gives the means and standard deviations of the response latencies and the mean error percentages for the distractor by SOA cells. Figure 7 shows the effects of the semantic, unrelated, and identical distractors relative to the control condition. The statistical analysis of the latencies yielded a main effect of distractor,

$F_1(3, 33) = 22.24$, $MSE = 489$, $p < .001$, $F_2(3, 93) = 27.01$, $MSE = 1,145$, $p < .001$, but not of SOA, $F_1(2, 22) = 1.67$, $MSE = 8,806$, $p > .21$, $F_2(2, 62) = 27.39$, $MSE = 1,429$, $p < .001$. The effect of distractor varied with SOA, $F_1(6, 66) = 7.32$, $MSE = 324$, $p < .001$, $F_2(6, 186) = 4.56$, $MSE = 1,432$, $p < .001$. Pairwise comparisons showed that the response times in the semantic condition and in the unrelated condition did not differ at any SOA ($ps > .18$). The latencies in the identical condition differed from those in the semantic condition at the SOAs of −150 ms and 0 ms ($ps < .001$), but not at SOA = 150 ms ($ps > .13$). The statistical analysis of the error rates yielded no significant results.

To conclude, if grammatical gender assignment requires concept selection, the distractor words should have yielded Stroop-like and semantic effects, just as they did with picture naming in Experiment 1B. The absence of a semantic effect in the present experiment suggests that grammatical gender is stored lexically. Thus, the results support the conclusion from Experiment 1A that context pictures activate the lemmas of their names.

WEAVER++ SIMULATIONS

According to Bloem and La Heij (2003), models such as WEAVER++ are able to account for semantic interference induced by distractor words, but not for semantic facilitation induced by distractor pictures. However, elsewhere it was shown that WEAVER++ successfully simulates

Table 6. *Mean response latencies*[a] *and error percentages per distractor and SOA for Experiment 5*

| | SOA | | | | | | | | | | | |
| | −150 | | | 0 | | | 150 | | | Total | | |
Distractor	M	SD	E%	M	SD	E%	M	SD	E%	M	SD	E%
Semantic	614	138	2.0	634	143	2.3	592	128	2.9	613	137	2.4
Unrelated	624	151	3.1	642	159	2.6	579	112	3.4	615	145	3.0
Identical	566	138	2.0	589	129	2.9	579	118	2.9	578	129	2.6
Control	596	104	4.4	607	133	3.1	583	122	3.4	595	120	3.7

Note: SOA = stimulus onset asynchrony. E% = error percentage.
[a]In ms.
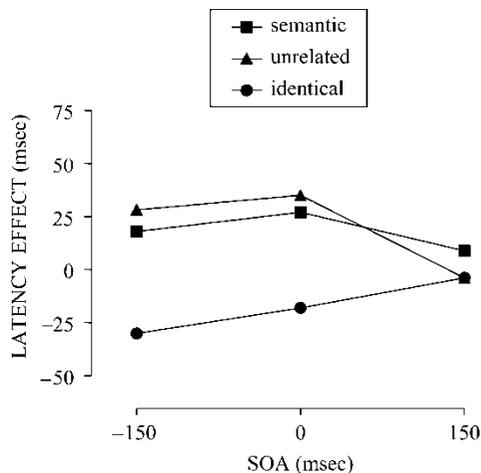
Figure 7. *Latency effects for generating gender-marked noun phrases in response to written words in the context of word distractors in Experiment 5. Depicted are the effects of semantic, unrelated, and identical distractors relative to control.*

both the semantic interference from distractor words in picture naming and the semantic facilitation from distractor pictures in responding to words, in particular, in categorizing words (Roelofs, 1992, 2003). Bloem and La Heij (2003) argued that these simulations are problematic, because the model assumes that in categorizing words (e.g., saying "furniture" to the word BED) competition is restricted to the lemmas of words that are potential responses (e.g., *furniture* and *animal* compete, but *furniture* and *bed* do not). For example, a pictured chair activates the concept FURNITURE(X) and indirectly the lemma of the target *furniture*, but the lemma of *chair* does not compete with *furniture* for selection in the model. In contrast, a pictured cat activates the concept ANIMAL(X) and indirectly the lemma of *animal*, which competes with *furniture* for selection. As a result, semantic facilitation is obtained in the model, as empirically observed. The role of the response set in picture–word interference is a hotly debated issue (e.g., Caramazza & Costa, 2000, 2001; Roelofs, 2001). However, the explanation by WEAVER++ of the semantic facilitation is independent of the response set assumption in the model, as is shown next.
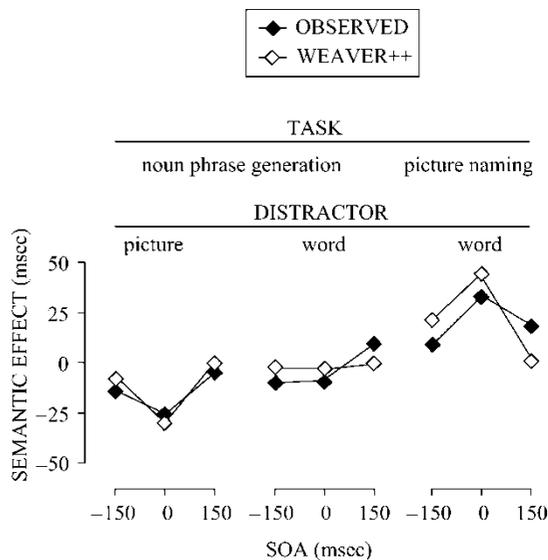
Figure 8. *Semantic effects for generating gender-marked noun phrases in response to written words in the context of picture distractors in Experiment 1A (left panel), generating gender-marked noun phrases in response to written words in the context of word distractors in Experiment 5 (middle panel), and naming pictures in the context of word distractors in Experiment 1B (right panel). Depicted are the observed effects and WEAVER++ simulation results.*

Figure 8 shows the results of WEAVER++ simulations of the semantic facilitation and interference effects in the present experiments. In Experiments 1–5, the distractors were always potential responses, which was therefore also assumed in the WEAVER++ simulations. The network structure and parameter values of the current simulations were identical to those reported in Roelofs (2003) except for a correction of the alignment of the mental and experimental SOAs in the model (cf. Roelofs, 1997), which was set at −150 ms for noun phrase generation.

The left panel of Figure 8 shows the results of the simulations of the present Experiment 1A. Semantic facilitation is obtained from picture distractors in responding to words (i.e., noun phrase generation), both empirically and in WEAVER++ simulations, despite the fact that all distractors were potential responses. The middle panel of Figure 8 shows the results of the

simulations of the present Experiment 5. No semantic effect is obtained from distractor words in responding to words (i.e., noun phrase generation) in the WEAVER++ simulations, and the same holds for the empirical results. The right panel of Figure 8 shows the semantic interference half of the semantic relatedness paradox. The panel shows the results of the WEAVER++ simulations of the present Experiment 1B. Semantic interference is obtained from word distractors in picture naming, both empirically and in WEAVER++ simulations. The correlation between simulated and observed latency effects is $r = .85$ ($N = 9$), with $p < .004$. To conclude, WEAVER++ accounts for the semantic interference from distractor words and for the semantic facilitation from distractor pictures.

GENERAL DISCUSSION

In the experiments reported in this article, it was investigated which aspects of words are activated in memory by context pictures and words. Context pictures yielded Stroop-like and semantic effects on response times when speakers generated gender-marked noun phrases in response to written words (Experiment 1A). However, the same distractor pictures yielded no such effects when speakers simply read aloud the noun phrases (Experiment 2). Moreover, context pictures yielded a gender congruency effect in generating gender-marked noun phrases in response to the written words (Experiments 3A and 3B). These findings suggest that context pictures activate the lemmas of their names, which leads to facilitation when the lemmas need to be accessed to generate a response (Experiments 1A, 3A, and 3B) but not when lemmas are not required for responding (Experiment 2). Objects appear to activate the lemmas of their names regardless of whether a speaker wants to name them.

Context words yielded Stroop-like and semantic effects in picture naming (Experiment 1B). Moreover, context words yielded Stroop-like but no semantic effects in reading nouns (Experiment 4) and in generating noun phrases (Experiment 5).

These findings suggest that context words activate the lemmas and forms of their names, which leads to semantic effects when lemmas are required for responding (Experiment 1B) but not when only the forms are required (Experiment 4). Moreover, the absence of semantic effects of words in generating noun phrases (Experiment 5) suggests that grammatical gender information is stored lexically rather than conceptually.

According to WEAVER++ , when lemmas are not selected to accomplish a reading task, the response is generated via the form level (Route B in Figure 1). Moreover, only the form of a selected lemma becomes activated. Thus, activation induced by pictures at the conceptual level will not reach the word form level. Consequently, distractor pictures do not affect word reading, in agreement with what has been reported in the literature (e.g., Glaser & Düngelhoff, 1984) and what was observed in Experiment 2. Is the assumption of task-dependent lemma selection really needed to explain the absence of an effect of picture distractors on word reading? One may argue, instead, that distractor pictures have no effect because word reading is so much faster than deriving a word from a picture. Consequently, word form activation by the picture simply comes too late to have an effect. Moreover, words may be read sublexically ("outside the lexicon", as it is traditionally called), via the application of grapheme-to-phoneme correspondence rules. Perhaps this shields word reading from interference by distractor pictures.

However, the speed of reading per se is insufficient to explain the absence of an effect of picture distractors. When picture distractors are presented 400 ms before the target word, making up for the difference in speed between deriving a name from a picture and a word, still no effect of pictures on word reading is obtained (e.g., Glaser & Düngelhoff, 1984). Moreover, effects of pictures on word reading are obtained when speakers have to switch from picture naming to word reading during a trial (Peterson & Savoy, 1998; Roelofs, 2003). This demonstrates that the immunity of reading to picture distractors is not absolute but task dependent. Moreover, the

absence of an effect of pictures on word reading cannot be due to the application of grapheme-to-phoneme correspondence rules. As with picture naming, response set effects are obtained in the word–word task (the task used in Experiment 4), as shown by Glaser and Glaser (1989). This suggests that the form route for reading (Route B in Figure 1) includes a lexical rather than only a sublexical mapping of print onto speech. In sublexical reading, the identities of the words involved should play no role, which leaves the response set effects unexplained. Moreover, Roelofs (2006) observed that dice and digits exhibit an asymmetry that is similar to the picture–word asymmetry. Digit and word distractors affect dice naming, but dice distractors do not affect digit and word naming. However, digits cannot be named via the application of grapheme-to-phoneme correspondence rules. This suggests that the immunity of word reading to picture distractors is not due to the application of grapheme-to-phoneme correspondence rules.

The findings from the present Experiments 1A, 2, 3A, and 3B suggest that pictures activate their lemmas but not the word forms. However, evidence from Morsella and Miozzo (2002) suggests that word forms are activated by context pictures in a picture–picture task. Speakers were presented with pictures in green superimposed onto pictures in red. The task was to name the pictures in green while ignoring the pictures in red. The picture names were phonologically related or unrelated. It was observed that target pictures were named faster when the distractor picture was phonologically related than when it was unrelated. This suggests that a distractor picture activates the phonological form of its name. Recently, Navarrete and Costa (2005) replicated the phonological facilitation obtained by Morsella and Miozzo (2002), whereas Bloem et al. (2004) were unable to replicate the effect.

Little is known about how participants deal with the selective attention problem posed by naming one of two superimposed pictures. Bloem et al. (2004) suggested that the participants in Morsella and Miozzo's (2002) experiment erroneously selected the context picture on some

of the trials, yielding the phonological effect. Another possibility is that the participants planned the names of both pictures, but only initiated articulation of the name of the green picture. According to this view, the phonological facilitation arises because of a particular planning strategy. Strategies may differ between experimental situations, which may explain why picture–picture effects vary between experiments. The variability holds not only for phonological effects but also for semantic effects. For example, whereas Glaser and Glaser (1989) obtained semantic interference from picture distractors in picture naming (the target was indicated by timing), Damian and Bowers (2003) obtained no effect (the target was indicated by size), and Bloem and La Heij (2003) referred to unpublished experiments from their own laboratory that yielded semantic facilitation. Given that picture–picture effects vary between experiments, it seems important to determine in future research what the exact conditions are for obtaining the semantic effects (Glaser & Glaser, 1989) and the phonological effects (Morsella & Miozzo, 2002; Navarrete & Costa, 2005).

Distractor pictures yielded semantic effects and gender congruency effects in noun phrase generation (Experiments 1A, 3A, and 3B) but not in noun phrase reading (Experiment 2). This suggests that distractor pictures activate the lemmas of their names. Schiller and Caramazza (2003) argued that the gender congruency effect of distractor words in picture naming arises because of competition between the determiner derived from the distractor word and the determiner needed for the picture. This raises the question of whether the present gender congruency effects are due to determiner competition. This cannot be the case, however. If the gender congruency effects in Experiments 3A and 3B arose because of competition between the determiner derived from the distractor picture and the determiner needed for the word, then the absence of an effect of picture distractors on noun phrase reading in Experiment 2 remains unexplained. When participants covertly derive the determiner of the name of context pictures, they can also be expected to covertly name the pictures.

However, the results from Experiment 2 suggest that the word form of the name of a distractor picture is not activated, whereas the results from Experiments 3A and 3B suggest that distractor pictures still yield a gender congruency effect. Thus, the gender congruency effects in Experiments 3A and 3B must arise in lemma retrieval.

One may argue that determiners and nouns occur together so often that speakers do not have to access gender information in memory. Instead, the determiner is activated by the noun through direct association. This may explain the gender congruency effect in Experiments 3A and 3B without having to assume that lemmas are involved. However, the problem with a direct association between nouns and determiners is that it leaves the semantic effect obtained in Experiment 1A unexplained. The semantic effect suggests that speakers accessed the mental lexicon.

Reading via the form level (Route B in Figure 1) explains why distractor words yield a Stroop-like effect but not a semantic effect in word reading (Experiment 4). This raises the question, however, of why semantic effects of words on word reading are typically absent in Stroop-like experiments (e.g., Glaser & Glaser, 1989), whereas they are reported for "semantic priming" studies of oral reading (e.g., Neely, 1991). One of the differences between these two types of study is that Stroop-like experiments massively repeat a small set of targets and distractors, whereas semantic priming experiments contain many items with few (if any) repetitions. Perhaps participants in semantic priming experiments base their reading response on a more complete processing of the target word than do participants in Stroop-like reading experiments, which may lead to an involvement of the lemma level in semantic priming but not in Stroop-like reading experiments. Reading via the lemma level is by itself insufficient to yield semantic effects in WEAVER++ , as we saw earlier (middle panel of Figure 8). However, semantic effects of words on reading may occur at long preexposure SOAs in the model.

In a classic series of experiments testing for semantic priming effects by words on responding to words, Lupker (1984) found a small 7-ms

semantic facilitation effect on oral reading and a much larger, robust 26-ms semantic facilitation effect when the task was lexical decision rather than oral reading. The SOA was −800 ms. In a review of the semantic priming literature, Neely (1991) noted that the size of the effects for the two tasks in the Lupker (1984) study—a small (if any) effect for oral reading and a larger effect for lexical decision—is typical. Figure 9 gives the results of WEAVER++ simulations of the oral reading and lexical decision experiments of Lupker (1984). The simulated SOA was −800 ms—the SOA used in the study of Lupker. In the simulations of the lexical decision task, WEAVER++ decided that a stimulus was a word when the activation of one of the lemmas exceeded a certain response threshold (set at 5.0 in the simulations). The parameter "distractor duration" in the simulations was set at 500 ms for both tasks. This parameter determines the gain of the prime input relative to the target input (Roelofs, 2003). Figure 9 shows that WEAVER++ captures the relative size of the effects in the oral reading and lexical decision tasks.

To conclude, the results from Experiments 1–3 suggest that perceived objects activate the lemmas
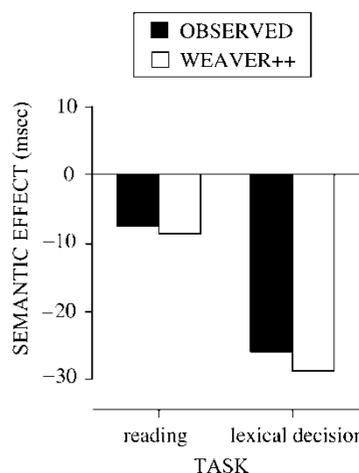
Figure 9. *Semantic effects of word primes in oral reading and lexical decision. Depicted are the effects observed by Lupker (1984, Exps. 2 and 5) and WEAVER++ simulation results. The SOA was −800 ms.*

of their names regardless of whether a speaker wants to name them, whereas the word forms are not significantly activated. The results from Experiments 4 and 5 suggest that perceived words activate the lemmas and the forms of their names regardless of whether a speaker wants to name them. Computer simulations showed that WEAVER++ successfully simulated the pattern of results.

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APPENDIX

Materials of the experiments

| | Target | Article | Distractor | | |
			Semantic	Unrelated	Identical
Animals	zwaan (swan)	de	schildpad	rok	zwaan
	schildpad (tortoise)	de	zwaan	beker	schildpad
	konijn (rabbit)	het	hert	paleis	konijn
	hert (deer)	het	konijn	bureau	hert
Clothing	trui (sweater)	de	rok	dolk	trui
	rok (skirt)	de	trui	zwaan	rok
	hemd (shirt)	het	vest	oor	hemd
	vest (vest)	het	hemd	kasteel	vest
Transportation	fiets (bike)	de	trein	kast	fiets
	trein (train)	de	fiets	arm	trein
	schip (ship)	het	vliegtuig	been	schip
	vliegtuig (plane)	het	schip	glas	vliegtuig
Buildings	molen (windmill)	de	fabriek	kom	molen
	fabriek (factory)	de	molen	neus	fabriek
	kasteel (castle)	het	paleis	vest	kasteel

APPENDIX (Continued)

	Target	Article	Distractor		
			Semantic	Unrelated	Identical
	paleis (palace)	het	kasteel	konijn	paleis
Weapons	dolk (dagger)	de	speer	trui	dolk
	speer (spear)	de	dolk	tafel	speer
	kanon (cannon)	het	pistool	bord	kanon
	pistool (pistol)	het	kanon	bed	pistool
Service	beker (cup)	de	kom	schildpad	beker
	kom (bowl)	de	beker	molen	kom
	glas (glass)	het	bord	vliegtuig	glas
	bord (plate)	het	glas	kanon	bord
Furniture	tafel (table)	de	kast	speer	tafel
	kast (cupboard)	de	tafel	fiets	kast
	bed (bed)	het	bureau	pistool	bed
	bureau (desk)	het	bed	hert	bureau
Body parts	arm (arm)	de	neus	trein	arm
	neus (nose)	de	arm	fabriek	neus
	been (leg)	het	oor	schip	been
	oor (ear)	het	been	hemd	oor