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To what extent do we process the nondominant object in a morphed figure? Evidence from a picture-word interference task

Mijke O. Hartendorp[ab], Stefan Van der Stigchel[a] & Albert Postma[ac]

[a] Experimental Psychology, Helmholtz Institute, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands

[b] Cognitive Systems, INCAS[3], Dr. Nassaulaan 9, 9401 HJ Assen, The Netherlands

[c] Department of Neurology, University Medical Center Utrecht, Heidelberglaan 100, 3584 CX Utrecht, The Netherlands

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To what extent do we process the nondominant object in a morphed figure? Evidence from a picture–word interference task

Mijke O. Hartendorp[1,2], Stefan Van der Stigchel[1], and Albert Postma[1,3]

[1]Experimental Psychology, Helmholtz Institute, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands
[2]Cognitive Systems, INCAS[3], Dr. Nassaulaan 9, 9401 HJ Assen, The Netherlands
[3]Department of Neurology, University Medical Center Utrecht, Heidelberglaan 100, 3584 CX Utrecht, The Netherlands

To investigate to what extent response candidates are processed during visual object categorisation, two picture–word interference tasks were conducted in which the effects of different types of distractor words on object naming were examined. Distractor words were related to the dominant or the nondominant object in a morphed figure. We assume both the dominant and nondominant object to be response candidates during response competition. The distractor words were identical (dog-dog), semantically related (cow-dog), or unrelated (spoon-dog) to the dominant or nondominant object. It was found that in relation to the dominant object in a morphed figure identical distractors facilitated naming, whereas semantically related distractors caused interference indicating a general semantic interference effect. Moreover, in relation to the nondominant object identical words interfered with naming, whereas semantically related words only interfered with naming when they were response set members. Therefore, identical words in general influenced the activation of the nondominant response candidate, whereas semantically related words only did so under restricted conditions. The latter will be discussed in terms of short-term memory load. Overall, we conclude that the nondominant response candidate is processed up to the perceptual level.

Keywords: Object categorisation; Visual perception; Morphed figures; Picture–word interference task.

To understand the process of visual object categorisation, it is important to gain insight in the stages *before* an overt response is given. Several theoretical models (Bar, 2003; Lamberts, 1995; Malt, Ross, & Murphy, 1995; Medin & Schaffer, 1978; Nosofsky, 1984; Panis, Vangeneugden, & Wagemans, 2008) have proposed that multiple interpretations are activated when categorising objects. For instance, the model by Bar (2003) suggests that a number of response candidates are activated from the stored concepts that show shape similarity to the visual input. The response candidate with the strongest match to the visual input wins the competition for categorisation. Because the matching concerns only shape similarity between visual input and stored concepts, the

Correspondence should be addressed to Mijke Hartendorp, Cognitive Systems, INCAS[3], Dr. Nassaulaan 9, 9401 HJ Assen, The Netherlands. E-mail: MijkeHartendorp@incas3.eu

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perceptual information of the response candidates should at least be activated. It is unclear, however, whether other information related to the activated response candidates, such as category membership (e.g., *dog* and *animal*) or functionally related items (e.g., *dog* and *barking*) is also activated. Therefore, the goal of the current study was to investigate up to what level the response candidates are activated during response competition. Are they just activated at a perceptual level, or also at a semantic level? For instance, when the visual input shows shape similarity to the concept *dog*, does the response candidate representing the concept *dog* only contain perceptual information about the concept *dog* (e.g., *snout*, *four legs*, *tail*) or also related information (e.g., *animal*, *cat*, *bone*)?

As has been demonstrated by many priming studies (Balcetis & Dale, 2007; Bar & Biederman, 1998; Bugelski & Alampay, 1961; Dell'Acqua & Grainger, 1999; Goolkasian, 1987; Jemel, Pisani, Calabria, Crommelinck, & Bruyer, 2003; Leeper, 1935; Palmer, 1975), presenting the visual input in a related context facilitates selection of a particular response candidate. The primes affect the categorisation process by reducing the time necessary to categorise the visual object and even by changing the interpretation of the visual input towards the preceded context. The previously mentioned priming studies showed that the categorisation process is not only affected by repetition priming (dog-dog), but can also be influenced by semantic priming (cow-dog). However, it remains to be determined whether context influences only the selected response candidate or nonselected response candidates as well.

Additional evidence for a context effect on the categorisation process comes from picture–word interference tasks. In these tasks, it has been revealed that the naming of pictures is influenced by superimposed words semantically related (also referred to as semantic-coordinate) to the picture (Glaser & Düngelhoff, 1984; Sailor, Brooks, Bruening, Seiger-Gardner, & Guterman, 2009). Here, semantically related words refer to objects that belong to the same category as the object represented by the target picture. Remarkably, they yield interference effects. For example, the semantically related distractor word *cow* slows down the naming of a picture of a dog, because they belong to the same semantic category (i.e., *animal*), whereas the identical distractor word *dog* facilitates naming of the picture of a dog. In addition to the semantic-coordinate relation between pictures and words, other relations between pictures and words have been tested, such as an associative relation (DOG and *flee*; Alario, Segui, & Ferrand, 2000; La Heij, Dirkx, & Kramer, 1990), a parts-of relation (CAR and *engine*; Costa, Alario, & Caramazza, 2005), and a functional relation (BED and *to sleep*; Kuipers & La Heij, 2008; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007). These types of relations differ from the semantic-coordinate relation in the sense that they cause semantic facilitation, whereas the semantic-coordinate relation leads to semantic interference (but see also Mahon et al., 2007).

An ongoing debate within the literature on language production concerns the locus of the semantic interference effect. Some argue that semantic knowledge is already coactivated in an earlier stage of the naming process, such as suggested by the lexical selection by competition account (Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992; Starreveld & La Heij, 1996). In this account, both picture and distractor words activate their own lexical representation that will compete at the lexical level for verbal response production. However, the picture will also activate (semantically) related lexical representations leading to stronger activation of the lexical node of a (semantically) related word. Moreover, others argue that this kind of information interferes with the naming process after a response has been selected, see for instance the conceptual selection model (CSM; Bloem & La Heij, 2003; Bloem, van den Boogaard, & La Heij, 2004). According to this model, semantic interference also takes place at the lexical level due to spreading activation causing interference when the distractor word is semantically related. However, only the selected concepts will reach the lexical level. In contrast, some argue that the locus of semantic interference is at the final stage of the production process where only one output can be articulated at a time, as is described by the response exclusion hypothesis (Mahon et al., 2007). According to this hypothesis, the naming latencies reflect the time necessary to exclude production-ready representations as potential responses to the target picture (see also Dell, Oppenheim, & Kittredge, 2008, who discus lexical access in relation to sentence production instead of single word production). The hypothesis is predominantly based on analysing speech errors occurring naturally or produced by aphasic patients.

Conventionally, picture–word interference tasks use objects that can easily be identified (e.g., "highly familiar objects" in Glaser & Düngelhoff, 1984, p. 643; "The pictures of the objects satisfied the following criteria: (1) subjects spontaneously named the pictures with the intended names" in Roelofs, 1992, p. 130) and as such cannot reveal whether semantic information is only activated for the preferred response candidate or also for alternative response candidates. Hence, the aim of the current study was to investigate to what extent multiple response candidates are processed during visual object categorisation, by examining up to what level semantic information affects the processing of alternative response candidates. If distractor words identical to an alternative response candidate influence the naming process, alternative response candidates are processed at least up to the perceptual level. Moreover, if distractor words semantically related to an alternative response candidate do not bias naming latencies or the types of errors made, this would indicate that alternative response candidates are not processed further, up to a semantic level. In contrast, if distractors semantically related to the alternatives do affect the naming process, this would suggest that response candidates, independent of being the preferred or an alternative one, are processed up to a semantic level.

To investigate to what degree repetitive and semantic information influence the activation of (alternative) response candidates, we need visual stimuli that activate a known set of multiple response candidates. Ideal stimuli are, therefore, morphed figures, because they allow at least two interpretations, namely an interpretation corresponding to the *dominant object* and an interpretation corresponding to the *nondominant object*. For instance, when morphing a *car* into a *turtle*, an 80%20% figure consists of 80% *car* (dominant object) and 20% *turtle* (nondominant object), whereas a 40%60% figure consists of 40% *car* (nondominant object) and 60% *turtle* (dominant object). It is important to note that the percentages reflect only morphing percentages, that is, they do not necessarily reflect human perception. Morphed figures are often categorised as their dominant object (i.e., categorical perception: Beale & Keil, 1995; Bornstein & Korda, 1984; Harnad, 1987; Hartendorp et al., 2010; McCullough & Emmorey, 2009; Newell & Bülthoff, 2002). Hence, we may consider the dominant object as the *preferred response candidate* (final output, response candidate that has won the response competition). It is likely that the nondominant object is one of the *alternative response candidates* (the response candidates that have lost the response competition), if any, since a morphed figure also contains visual information of the nondominant object. This assumption has been reinforced by a recent finding of Daelli, van Rijsbergen, and Treves (2010). They have shown that the categorisation of morphed figures changed when a morphed figure was preceded by its nondominant object, suggesting that the nondominant object is indeed one of the response candidates.

We conducted a picture–word interference task in which the distractor words were identical, semantically related or unrelated to the dominant and nondominant object of a morphed figure to investigate which type of context has an effect on the activation of the nondominant response candidate. For example, if the morphed figure is a 70%30% figure of the *Car-Turtle* series, the identical words will be *car* and *turtle*, the semantically related words *train* and *frog*, and the unrelated words *hammer* and *suitcase* for the dominant and nondominant object, respectively. We used identical words to examine the influence of repetitive context on the categorisation process (dog-dog) and the semantically related words examined the influence of semantic context on the categorisation process (cow-dog). The unrelated words functioned as a baseline to which the effects of the identical and semantically related words could be compared. Earlier research showed that the preferred response candidate is the dominant object (Harnad, 1987; McCullough & Emmorey, 2009; Verstijnen & Wagemans, 2004), so we expected the distractor words related to the dominant object to have similar effects on the categorisation process as the effects reported in previous picture–word interference tasks (Glaser & Düngelhoff, 1984; Sailor et al., 2009). In other words, dominant identical words should facilitate naming of a morphed figure and dominant semantically related words should interfere with naming. Most importantly, the distractor words related to the nondominant object of a morphed figure directly revealed to what extent the alternative response candidates were activated. If the alternative response candidates, e.g., the nondominant object, are only represented at a perceptual level, we would expect only nondominant identical words to interfere with naming. However, if the alternative response candidates, e.g., the nondominant object, also contain semantic information, we might anticipate the nondominant semantically related words to have an effect on naming as well. Two picture–word interference tasks were conducted.

In Experiment 1, only the identical words were members of the response set. The semantically related and unrelated words did not. In Experiment 2, we controlled for possible response set effects (La Heij, 1988) by using a stimulus set in which all distractor words were part of the response set.

EXPERIMENT 1

Method

Participants

Thirty students from Utrecht University participated in this experiment and received 3 Euros or a course credit for their contribution. The experiment lasted about half an hour.

Materials

Morphed figures were created from black silhouette objects (filled line drawings) that were presented on a white background. These silhouette objects were selected from a large set of contour drawings of a wide range of living and nonliving objects for which normative identification rates had been established (De Winter & Wagemans, 2004; Wagemans et al., 2008), which in turn were derived from an earlier set of line drawings validated by Snodgrass and Vanderwart (1980). Additionally, one figure (i.e., the *man* figure) was selected from a set of contour drawings by Downing, Bray, Rogers, and Childs (2004). Pairs of silhouette objects were interpolated in steps of 5% change using Sqirlz-Morph software (Xiberpix, version 2.0), resulting in morph series consisting of 19 interpolations and two extremes, the 100% figures (cf. Hartendorp et al., 2010, for a description of the morphing procedure). All paired extremes were from different (basic-level) categories and most of them from different superordinate categories (for an explanation of different levels of categorisation, see Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). To reduce exposure to the same series as much as possible, only six out of the 19 interpolations from each series were included as stimulus materials: the 80%20%, 70%30%, 60%40%, 40%60%, 30%70%, and 20%80% figures (approximately 4.29° × 3.34°, 7 cm × 9 cm). Equivalent morphing levels were collapsed, since we assumed that response patterns would not differ in general for the two equivalent figures. The morphing levels were reduced to three levels, namely to the 80%20%, 70%30%, and 60%40% morphing level, with the 80%20% morphing level containing the 80%20% and 20%80% figures, the 70%30% morphing level containing the 70%30% and 30%70% figures, and the 60%40% morphing level containing the 60%40% and 40%60% figures. In total, nine different morph series were used (see Figure 1 for a complete overview of the stimulus materials).

The distractor words followed a number of restrictions. First, the identical words were similar to the basic-level name (Rosch et al., 1976) of the objects interpolated in the morphed figures. For example, the identical words for morphed figures of the *Car-Turtle* series were *car* and *turtle*.

Second, the semantically related words referred to objects that belonged to the same category as the interpolated objects in a morphed figure. However, they were required not to be strongly associated to the target object, because the impact of associative words differs from purely semantic words (Alario et al., 2000; La Heij et al., 1990). For example, the semantically related words for morphed figures of the *Car-Turtle* series were *train* and f*rog*: They belong to the same category (*vehicle* and *animal*, respectively), but their association is probably not as strong as the words *bicycle* and *beach*. The association between target picture and distractor word was tested by a pilot experiment in which 20 participants were asked to rate the strength of association between two words on a scale from 1 to 7 (1 = "no association" and 7 = "a very strong association"). For instance, the word *duck* was compared to the presumably associatively related word *pond*, to the presumably semantically related, but not associatively related word *bee* and to the presumably unrelated word *sweater*. The associative strength score average was highest for the associative pairs ($M = 5.67$ and $SD = 0.76$), followed by the semantically related pairs ($M = 3.87$ and $SD = 1.21$) and by the unrelated pairs ($M = 1.45$ and $SD = 0.32$), $t_{associative\text{-}semantic}(19) = 9.05$ and $p < .001$, $t_{associative\text{-}unrelated}(19) = 27.20$ and $p < .001$, $t_{semantic\text{-}unrelated}(19) = 10.13$ and $p < .001$.

Third, a semantically related and unrelated distractor word and their target's object name had to start with a different first letter and had to consist of approximately the same number of letters ($M_{identical} = 6.50$ and $SD_{identical} = 2.50$, $M_{semantic} = 5.50$ and $SD_{semantic} = 1.65$, $M_{unrelated} = 5.11$ and $SD_{unrelated} = 1.64$). By conducting a one-way ANOVA, $F_{letters}(2, 51) = 2.37$ and $p = .10$, and paired samples *t*-tests, $t_{identical\text{-}semantic}(17) = 1.77$

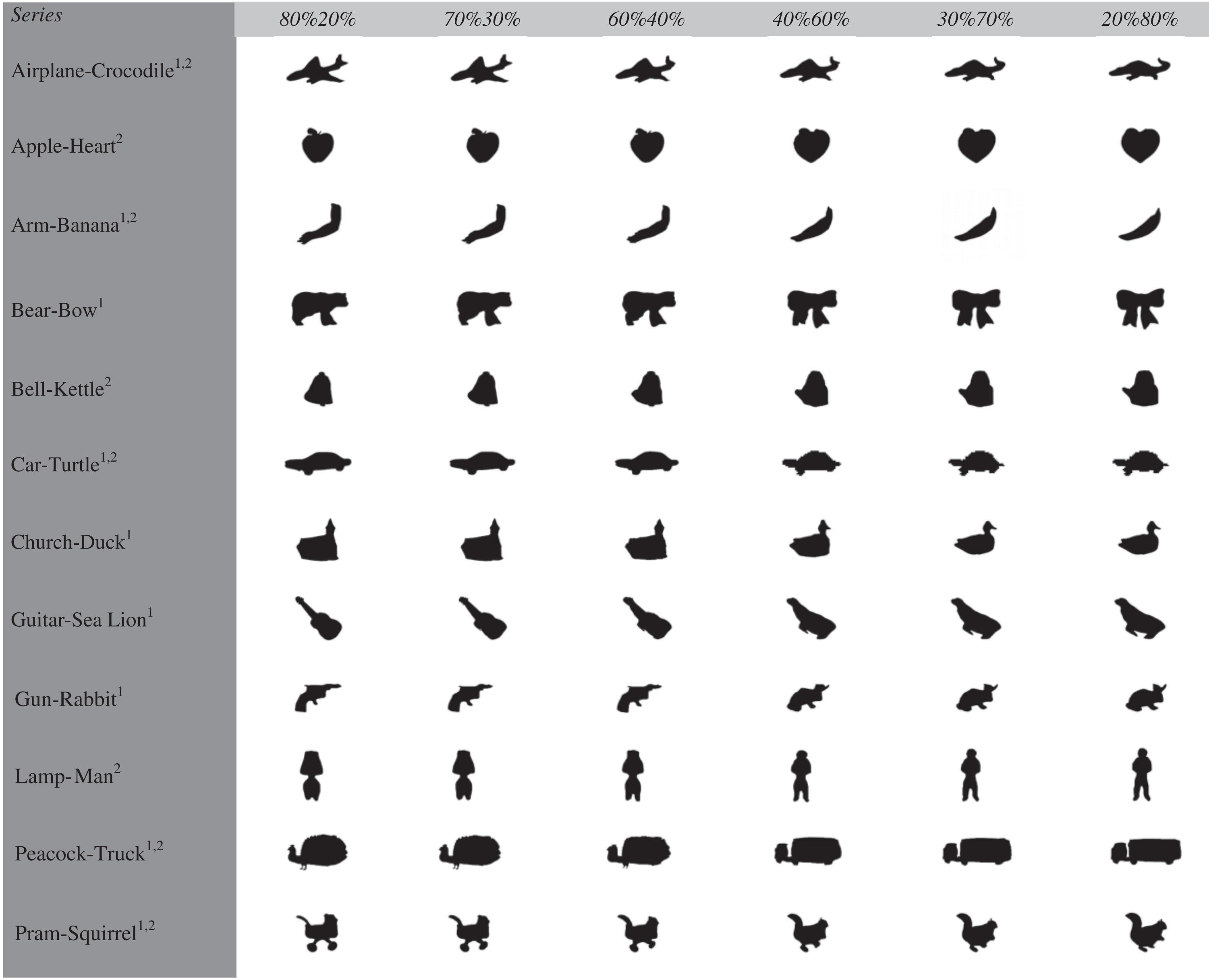

Figure 1. The morph series used as stimulus materials in Experiment 1 and 2. At the top of the table the different morphing levels are presented (i.e., 80%20%, 70%30%, 60%40%, 40% 60%, 30%70%, and 20%80%). At the left side of the table, the name of each morph series is presented referring to the object names of the extreme objects. Superscript numbers refer to the experiment in which the morph series functioned as stimulus materials ([1]refers to Experiment 1 and [2]to Experiment 2).

and $p = .10$, $t_{identical\text{-}unrelated}(17) = 2.02$ and $p = .06$, $t_{semantic\text{-}unrelated}(17) = 0.81$ and $p = .43$, it was shown that the number of letters did not differ between conditions. In addition, distractor words and their target's object names were required to consist of approximately the same number of syllables ($M_{identical} = 1.89$ and $SD_{identical} = 0.83$, $M_{semantic} = 1.50$ and $SD_{semantic} = 0.51$, $M_{unrelated} = 1.56$ and $SD_{unrelated} = 0.62$). Again, the number of syllables did not differ between the conditions, as was shown by a one-way ANOVA, $F_{syllables}(2, 51) = 2.03$ and $p = .14$, and paired samples *t*-tests, $t_{identical\text{-}semantic}(17) = 1.80$ and $p = .09$, $t_{identical\text{-}unrelated}(17) = 1.80$ and $p = .09$, $t_{semantic\text{-}unrelated}(17) = 0.00$ and $p = 1.00$. Furthermore, the distractor words and their target's object names were required to have approximately the same word frequency in Dutch; these were derived from SUBTLEX-NL (Keuleers, Brysbaert, & New, 2010), ($M_{identical} = 2227$ and $SD_{identical} = 4695$, $M_{semantic} = 1279$ and $SD_{semantic} = 1858$, $M_{unrelated} = 2718$ and $SD_{unrelated} = 3393$). Word frequency did not differ significantly between conditions as was shown by a one-way ANOVA, $F_{frequency}(2, 50) = 0.74$ and $p = .48$, and paired samples *t*-tests, $t_{identical\text{-}semantic}(16) = 0.98$ and $p = .34$, $t_{identical\text{-}unrelated}(17) = -0.34$ and $p = .74$, $t_{semantic\text{-}unrelated}(16) = -1.52$ and $p = .15$. Overall, any difference between the conditions (identical, semantically related, and unrelated) is unlikely to be a consequence of a difference in word length, number of syllables, and word frequency.

Fourth, the 18 unrelated words were restricted to be unrelated to all objects interpolated in the morphed figures, meaning that they should not belong to the same category and should have no (strong) association to any one of the presented objects. Unrelated words were always combined in random order with the figures from the morph series to ensure that participants did not learn a predictable connection between an unrelated distractor word and the figures of a particular morph series (see Appendix A for all distractor words). The unrelated words are assigned to either the dominant or nondominant conditions making it possible to compare the identical and semantically related conditions within a dominance type to the unrelated condition, though this does not mean that they are actually "related" to the dominant or nondominant object in a morphed figure. The stimuli were displayed using E-Prime (Psychology Software Tools Inc., version 1.1). Participants used a voice-key for responding and the experimenter used a stimulus–response box for rating the participants' response as either a dominant response, a nondominant response, an alternative response, or as a voice-key error.

Procedure

In this picture–word interference task, participants were asked to name a picture that was superimposed by a Dutch distractor word printed in red. The picture was always a morphed figure. The distractor word was related to the dominant or nondominant object of a morphed figure. Furthermore, the distractor word was identical, semantically related or unrelated to the target. For example, for a morphed figure consisting of 70% *church* (dominant object) and 30% *duck* (nondominant object), the identical words were *church* and *duck*, the semantically related words were *palace* and *bee*, and the unrelated words could be *newspaper* and *key*. An experimental run consisted of 324 experimental trials (9 morph series × 6 morphed figures × 6 distractor words). In advance, participants were familiarised with the pictures and their correct object names. These were the 100% figures (the extremes) that were used for the interpolation of the morph series. They were presented successively with their object name printed below the figure. Subsequently, participants were instructed to name the pictures as quickly and accurately as possible using the voice-key and to ignore the distractor word. Next, eight practice trials were presented containing nonexperimental stimuli that followed the same sequence as the experimental trials. First, a fixation cross was presented on the centre of the screen for 1500 ms. Subsequently, the target picture was presented (morphed figure) superimposed by a distractor word for a maximum of 2000 ms. The display cleared when a response was triggered. Next, the experimenter rated the verbal response of the participant, after which the next trial started. The target picture and distractor word were presented simultaneously (i.e., SOA 0), because in most studies a semantic interference effect was observed using an SOA close or equal to zero (Bloem & La Heij, 2003; La Heij et al., 1990; Mädebach, Oppermann, Hantsch, Curda, & Jescheniak, 2011; Sailor et al., 2009). The pictures and distractor words were presented in a pseudorandom order with the restriction that each consecutive trial contained a morphed figure of another morph series and another distractor word than the previous trial. After 108 trials a self-timed break was included.

TABLE 1
Mean RT in ms of the dominant responses and their standard error of the mean in brackets (also expressed in ms) across participants for each condition in Experiment 1

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	664 (15)	680 (16)	725 (19)
	Unrelated	777 (18)	796 (18)	819 (19)
	Semantic	797 (18)	842 (22)	850 (24)
Nondominant	Identical	795 (18)	817 (23)	865 (23)
	Unrelated	767 (18)	792 (17)	848 (23)
	Semantic	768 (16)	791 (17)	842 (21)

The columns represent the different morphing levels and the rows represent the different distractor word types. The first column refers to whether the distractor word is related to the dominant or nondominant object of the morphed figure and the second column refers to the type of relation between the distractor word and one of the objects in a morphed figure.

Results

From all responses, 91.2% was recorded as dominant responses, 5.0% as nondominant responses, 2.2% as alternative responses, and 1.7% as voice-key errors. The reaction times (RTs) in ms were analysed including only the dominant responses. The mean RT observed for the different conditions are presented in Table 1 for the participant means (F_1) and in Table 2 for the item means (F_2). Furthermore, the trials with an RT below 200 ms (2.2%) or above 3 standard deviations of the mean RT per subject (1.5%) were discarded from further analyses.

In addition, error analyses were performed on both the participant means (F_1) and item means (F_2) including only the dominant and nondominant responses to examine whether the proportions of dominant responses and the proportions of nondominant responses varied across conditions. The mean percentage of dominant responses observed for the different conditions are presented in Table 3 for the participant means and in Table 4 for the item means (adding up to 100% provides the percentages of nondominant responses).

Repeated measures ANOVAs were performed with morphing (three levels: 80%20%, 70%30%, or 60%40% figures), dominance (two levels: distractor word was related to dominant or nondominant object), and relation (three levels: distractor word was identical, semantically related, or unrelated) as within-subject variables for the participant means (F_1) and as within-series variables for the item means (F_2). Bonferroni corrected post hoc comparisons were performed for significant effects at an alpha level of .05.

The main effect of morphing was significant, $F_1(2, 58) = 67.40$, $p < .001$, partial $\eta^2 = .70$, and $F_2(2, 16) = 84.49$, $p < .001$, partial $\eta^2 = .91$. All morphing levels differed significantly from each other, with fastest RTs for 80%20% figures,

TABLE 3
Mean percentage dominant responses and their standard error of the mean in brackets (also expressed in percentages) across participants for all conditions in Experiment 1

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	99.8 (0.2)	97.9 (0.5)	94.6 (0.9)
	Unrelated	98.4 (0.5)	97.2 (0.6)	89.9 (1.3)
	Semantic	98.9 (0.4)	96.6 (0.8)	90.9 (1.3)
Nondominant	Identical	97.9 (0.6)	92.8 (1.6)	82.3 (1.6)
	Unrelated	98.6 (0.6)	96.7 (0.7)	89.1 (1.6)
	Semantic	97.7 (0.6)	97.3 (0.6)	90.3 (1.2)

See the footnote to Table 1 for an explanation of the headings.

TABLE 2
Mean RT in ms of the dominant responses and their standard error of the mean in brackets (also expressed in ms) across items for each condition in Experiment 1

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	662 (11)	679 (12)	726 (18)
	Unrelated	775 (11)	799 (20)	822 (17)
	Semantic	799 (16)	844 (16)	848 (15)
Nondominant	Identical	799 (25)	819 (28)	870 (25)
	Unrelated	769 (16)	792 (13)	854 (21)
	Semantic	769 (14)	793 (14)	848 (18)

See the footnote to Table 1 for an explanation of the headings.

TABLE 4
Mean percentage dominant responses and their standard error of the mean in brackets (also expressed in percentages) across items for all conditions in Experiment 1

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	99.8 (0.2)	97.9 (1.7)	94.9 (2.3)
	Unrelated	98.4 (0.9)	97.2 (1.9)	89.6 (2.7)
	Semantic	99.0 (1.0)	96.7 (1.7)	90.9 (3.6)
Nondominant	Identical	98.1 (1.1)	93.0 (2.2)	82.4 (3.6)
	Unrelated	98.6 (1.2)	96.8 (2.4)	89.1 (3.2)
	Semantic	97.9 (2.1)	97.4 (1.7)	90.4 (3.1)

See the footnote to Table 1 for an explanation of the headings.

followed by 70%30% figures, and slowest RTs for 60%40% figures. The main effect of dominance was significant, $F_1(1, 29) = 49.29$, $p < .001$, partial $\eta^2 = .63$, and $F_2(1, 8) = 52.35$, $p < .001$, partial $\eta^2 = .87$. Dominant distractor words resulted in faster RTs than nondominant distractor words. The main effect of relation was significant, $F_1(2, 58) = 43.44$, $p < .001$, partial $\eta^2 = .60$, and $F_2(2, 16) = 28.81$, $p < .001$, partial $\eta^2 = .78$. The RTs in the identical condition were shorter than in the semantically related and unrelated condition. The semantically related and unrelated words differed significantly for the participant means, with longer RTs obtained for the semantically related condition than for the unrelated condition. The latter did not differ significantly for the item means, though a marginal effect ($p = .08$) was revealed by the post hoc comparisons, showing a similar trend as was found for the participant means. The interaction effect of morphing and dominance was significant, $F_1(2, 58) = 4.81$, $p < .05$, partial $\eta^2 = .14$, and $F_2(2, 16) = 8.67$, $p < .01$, partial $\eta^2 = .52$. Despite the fact that all conditions differed significantly from one another according to the post hoc comparisons, this significant interaction effect is probably caused by the fact that the linear increase of RT from 80%20% to 70%30% and next to 60%40% morphing level observed for figures superimposed by a dominant distractor word was not observed for figures superimposed by a nondominant distractor word. For the nondominant distractor words, a steeper increase of RT is observed from 70%30% to 60%40% morphing level than from 80%20% to 70%30%. The interaction of morphing and relation was not significant, $F_1(4, 116) = 0.76$, $p > .05$, partial $\eta^2 = .03$, and $F_2(4, 32) = 0.95$, $p > .05$, partial $\eta^2 = .11$. This means that the effects reported earlier for the different relations between distractor words and morphed figure were not significantly different for the different levels of morphing.

Most importantly, the interaction effect of dominance and relation was also significant, $F_1(2, 58) = 102.75$, $p < .001$, partial $\eta^2 = .78$, and $F_2(2, 16) = 53.90$, $p < .001$, partial $\eta^2 = .87$. For the dominant distractor words, the identical words facilitated the naming of a morphed figure compared to the unrelated words ($p < .001$), whereas the semantically related words interfered with the naming of a morphed figure ($p < .01$). For the nondominant distractor words, an interference effect was observed for the identical words compared to the semantically related ($p < .01$) and unrelated words ($p < .05$). The semantically related and unrelated words did not differ ($p = 1.00$). Moreover, this difference was only found for the participant means. Although the RTs for the item means showed a similar pattern (longer RTs for the nondominant identical words in contrast to the nondominant semantically related and unrelated words), these conditions did not differ significantly ($p = .46$ and $p = .53$, respectively). The absence of a significant difference might be due to the small number of morph series. In Figure 2, this interaction effect is presented for the participant means.

The three-way interaction of morphing, dominance, and relation was not significant, $F_1(4, 116) = 0.99$, $p > .05$, partial $\eta^2 = .03$ and $F_2(4, 32) = 0.83$, $p > .05$, partial $\eta^2 = .09$. This suggests that the significant two-way interaction between dominance and relation was not modulated by level of morphing.

In addition, the error analysis was performed using the same within-subject variables as in the reaction time analysis. First, the main effect of morphing was significant, $F_1(2, 58) = 133.07$, $p < .001$, partial $\eta^2 = .82$, and $F_2(2, 16) = 13.24$, $p < .001$, partial $\eta^2 = .62$. All three morphing levels differed significantly with most dominant responses for the 80%20% figures and least dominant responses for the 60%40% figures. The main effect of dominance was also significant, $F_1(1, 29) = 42.50$, $p < .001$, partial $\eta^2 = .59$, and $F_2(1, 8) = 11.23$, $p < .05$, partial $\eta^2 = .58$, with more dominant responses to targets superimposed by a distractor word related to the dominant object than to the nondominant object. The main effect of relation was not significant, $F_1(2, 58) = 2.34$, $p = .11$, partial $\eta^2 = .08$, and $F_2(2, 16) = 2.28$, $p = .14$, partial $\eta^2 = .22$. The interaction effect of morphing and dominance was significant, $F_1(2, 58) = 7.92$, $p < .01$, partial $\eta^2 = .21$, and $F_2(2, 16) = 11.01$, $p < .01$, partial $\eta^2 = .58$. All conditions differed significantly from one another. The interaction effect of morphing and relation was not significant, $F_1(4, 116) = 1.90$, $p = .12$, partial $\eta^2 = .06$, and $F_2(4, 32) = 1.17$, $p = .34$, partial $\eta^2 = .13$. The interaction effect of dominance and relation was significant, $F_1(2, 58) = 19.64$, $p < .001$, partial $\eta^2 = .40$, and $F_2(2, 16) = 9.97$, $p < .01$, partial $\eta^2 = .56$. The proportion of dominant responses was higher in the identical condition than in the semantically related and unrelated condition for the dominant distractor words, though this only accounted for the participant means. In contrast, for the nondominant distractor words the proportion of dominant responses was lower in the identical

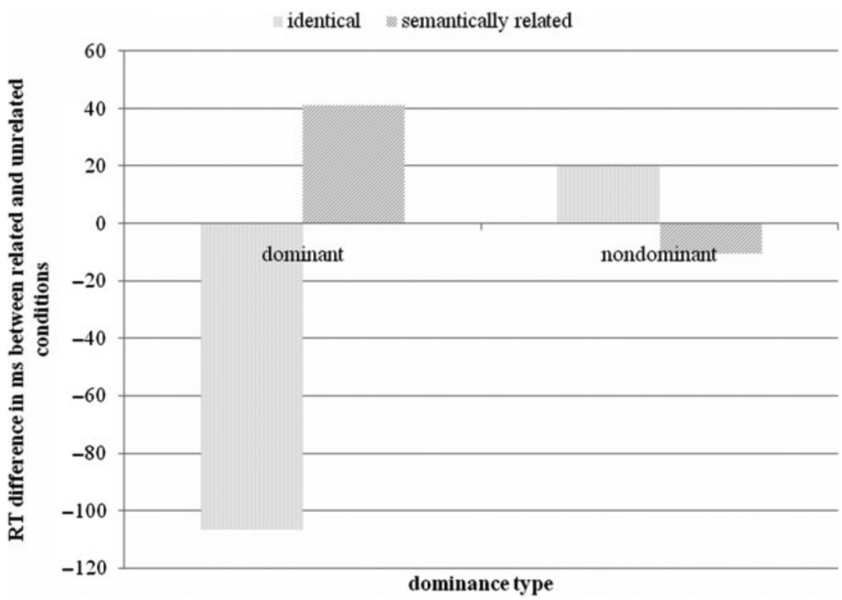

Figure 2. The differences in RT in ms between the related conditions and the unrelated condition for the interaction effect of relation and dominance in Experiment 1. The mean RT of the unrelated condition is subtracted from the mean RT of the related condition. Thus, a positive bar indicates longer RTs for the related condition compared to the unrelated condition, whereas a negative bar indicates shorter RTs for the related condition compared to the unrelated condition. The related condition is either the identical condition (light grey dotted bars, e.g., the distractor word *duck* for a morphed figure of the morph series *Duck-Church*) or the semantically related condition (dark grey striped bars, e.g., the distractor word *bee* for a morphed figure of the morph series *Duck-Church*). The related conditions are presented separately for the distractor words that are related to the dominant object (two left bars, e.g., the distractor word *duck* for the 70%30% figure of the *Duck-Church* morph series) and to the nondominant object of a morphed figure (two right bars, e.g., the distractor word *church* for the 70%30% figure of the *Duck-Church* morph series).

condition than in the semantically related and unrelated condition; this difference was observed for both participant and item means. The three-way interaction effect of morphing, dominance, and relation was also significant, $F_1(4, 116) = 5.94$, $p < .001$, partial $\eta^2 = .17$, and $F_2(4, 32) = 4.49$, $p < .01$, partial $\eta^2 = .36$.

Discussion

In the current experiment, a picture–word interference task was conducted in which the level of morphing of morphed figures was varied. In addition, distractor words were presented, which were identical, semantically related, or unrelated to either the dominant or the nondominant object in the morphed figure. The response latencies of the dominant responses were computed both over participants and over items. In general, the results of the item means were similar to those of the participant means, although not all effects that were significant for the participant means were significant for the item means. This lack of significance is probably due to the small number of morph series in our experiment. Although one expects items to be processed similarly, items will always differ. The variability between items plays a larger role when using a relatively small set size in comparison to a larger set size (see also La Heij & van den Hof, 1995, who studied the effects of set size in a picture–word interference paradigm). In addition, error analyses were performed to examine whether the proportion of dominant and nondominant responses varied across conditions. We found the following results: First of all, an increase of morphing level (from 80%20% to 60%40%) meant also an increase in response time and a decrease of dominant responses (and, therefore, an increase of nondominant responses). This corresponds to the idea that an increase of morphing level causes an increase of uncertainty that is expressed in longer response latencies. Furthermore, the distractor words related to the dominant object caused faster response times than the ones related to the nondominant object and more dominant responses. This is probably due to the stronger presence of the dominant object in a morphed figure than the nondominant object leading also to more influence of the distractor words related to the dominant object than related to the nondominant object. In addition, the identical words facilitated the naming process, whereas the semantically related words induced interference. The reported interaction between morphing and dominance was caused by a larger difference in reaction time between the 70%30% and 60% 40% conditions for the distractor words related to the nondominant object than for the distractor words related to the dominant object. This suggests that the nondominant object in a morphed figure is more strongly present in the 60%40% figure than in the 70%30% figure. As a consequence, distractor words related to the nondominant object have a greater impact on the naming process when they concern a figure at a 60%40% morphing level than at another morphing level. This might be explained by the increased perceptual uncertainty, leaving more space for interference (see also De Houwer, Hermans, & Spruyt, 2001). Most interestingly, an interaction was found between dominance and relation. For the distractor words related to the dominant object of a morphed figure, a facilitation effect was shown for the identical words and an interference effect for the semantically related words. Moreover, the distractor words related to the nondominant object showed a different effect on the naming latencies. The identical words interfered with the naming of the morphed figure, whereas semantically related words had no effect on the naming process. This suggests that the naming process of a morphed figure as its dominant object is facilitated by distractor words identical to the dominant object and is disturbed by distractor words semantically related to the dominant object. In contrast, the naming process is only affected by a nondominant distractor word when it is identical to the nondominant object. This is also reflected by the error analysis to some extent. If an identical distractor word is related to the dominant object the morphed figure is more often interpreted as its dominant object in comparison to a semantically and unrelated distractor word, whereas, if an identical distractor word is related to the nondominant object, the morphed figure is more often interpreted as its nondominant object in comparison to a semantically and unrelated distractor word.

EXPERIMENT 2

The context effects reported in Experiment 1, in particular the lack of semantic interference in the nondominant semantically related condition, might have been due to the fact that the semantically related words were not members of the response set, whereas the identical words always were part of the response set.[1] As La Heij (1988; see also La Heij, 1990; Levelt et al., 1999; Roelofs, 1992, 2001; but see also Caramazza & Costa, 2000, 2001) has shown, unrelated words that belong to the response set interfered more with naming than unrelated words that did not belong to the response set. This might be caused by the difference in strength of lexical activation between distractor words that are produced and repeated due to their response set membership and distractor words that are not produced and not repeated due to their nonmembership to the response set. In this experiment, therefore, in order to control for this effect we only used distractor words that were also part of the response set.

Method

Participants

Twenty-three students from Utrecht University participated in the current experiment. These were all different participants from the participants who volunteered for Experiment 1. Three of them were excluded from further analyses: two of them were nonnative speakers of Dutch and one of them did not respond within the restricted presentation time of a target (2000 ms) in about 30% of the trials. The experiment lasted about half an hour and participants received 3 Euros or a course credit for their contribution.

Materials

To control for possible response set effects (La Heij, 1988), only distractor words were used in the present experiment that were also object names of the extreme objects (100% figures) of the other experimental morph series. Due to the criterion that all distractor words should be part of the response set, extreme objects of the morph series used in the current experiment functioned both as semantically related and unrelated words. Partially other morph series were selected than the ones in Experiment 1 (see Figure 1), because the extreme objects of those morph series were not semantically related to any extreme object of the other experimental morph series. Pairs of morph series were selected of which the extremes were

[1] We would like to thank the anonymous reviewer for the suggestion to control for response set membership.

semantically related to one another. For example, the Car-Turtle series was coupled to the Peacock-Truck series: car and truck were both members of the category vehicle, and turtle and peacock were both members of the category animal. Four pairs of morph series were selected (see Appendix B). In addition, the unrelated distractor words belonged to the extreme objects that were not semantically related to the morph series in question (the morph series Arm-Banana, Apple-Heart, Bell-Kettle, and Lamp-Man functioned as unrelated words for the series Car-Turtle, Peacock-Truck, Airplane-Crocodile, and Pram-Squirrel, and vice versa). The pairs Bell-Kettle and Lamp-Man were not semantically related to each other, but were added to balance the distribution of unrelated words. Trials containing a morphed figure of one of these series were therefore not taken into account when analysing the data. For the complete response set, the average number of letters is $M_{letters}$ = 6.06 and $SD_{letters}$ = 2.84, the average number of syllables is $M_{syllables}$ = 1.88 and $SD_{syllables}$ = 0.89, and the average word frequency in Dutch (Keuleers et al., 2010) is $M_{frequency}$ = 6695 and $SD_{frequency}$ = 16,035. The number of letters, number of syllables, and word frequency were all equal between conditions (identical, semantically related, and unrelated), because every distractor word functioned as an identical, as a semantically related, and as an unrelated distractor word.

Procedure

The instructions and procedure in the current experiment were similar to the instructions and procedure of Experiment 1, except for the morph series and, therefore, the object pictures that were presented during the familiarisation phase. Furthermore, an experimental run now consisted of 288 trials instead of 324 trials due to the reduction in number of morph series from nine to eight. This also meant that after 96 trials (instead of 108) a self-timed break was included.

Results

From all responses, 89.8% was recorded as dominant responses, 5.1% as nondominant responses, 1.5% as alternative responses and 3.6% as voice-key errors. The reaction times (RTs) in ms were analysed including only the dominant responses and excluding the trials containing a figure of one of the series Bell-Kettle and Lamp-Man. The trials with an RT below 200 ms (0.4%) and above 3 standard deviations of the mean RT per subject (1.6%) were discarded from further analyses. The mean RTs found for the different conditions are presented in Table 5 for the participant means and in Table 6 for the item means.

In addition, error analyses were performed including only the dominant and nondominant responses to examine whether the proportions of dominant responses and the proportions of nondominant responses varied across conditions. The mean percentages of dominant responses found for the different conditions are presented in Table 7 for the participant means and in Table 8 for the item means.

The same variables were used as in Experiment 1. Repeated measures ANOVAs were performed with morphing (80%20%, 70%30%, and 60%40% figures), dominance (word related to dominant or nondominant object), and relation (identical, semantically related, and unrelated) as within-subject variables for the participants means (F_1) and as within-series variables for the item means (F_2). Subsequently, Bonferroni corrected post hoc

TABLE 5
Mean RT in ms of the dominant responses and their standard error of the mean in brackets (also expressed in ms) across participants for each condition in Experiment 2

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	707 (27)	724 (26)	804 (28)
	Unrelated	828 (21)	811 (25)	849 (30)
	Semantic	836 (21)	846 (26)	888 (29)
Nondominant	Identical	840 (26)	855 (23)	915 (25)
	Unrelated	796 (24)	838 (24)	844 (29)
	Semantic	820 (24)	856 (26)	899 (31)

See the footnote to Table 1 for an explanation of the headings.

TABLE 6
Mean RT in ms of the dominant responses and their standard error of the mean in brackets (also expressed in ms) across items for each condition in Experiment 2

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	705 (9)	723 (14)	799 (17)
	Unrelated	826 (32)	813 (26)	849 (16)
	Semantic	838 (25)	842 (21)	895 (24)
Nondominant	Identical	841 (19)	860 (27)	927 (27)
	Unrelated	797 (16)	840 (24)	854 (35)
	Semantic	825 (24)	859 (30)	901 (11)

See the footnote to Table 1 for an explanation of the headings.

TABLE 7
Mean percentage dominant responses and their standard error of the mean in brackets (also expressed in percentages) across participants for all conditions in Experiment 2

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	99.1 (0.6)	97.9 (0.8)	95.7 (1.2)
	Unrelated	98.3 (0.8)	97.7 (1.1)	95.8 (1.2)
	Semantic	99.2 (0.6)	95.4 (1.4)	91.5 (1.3)
Nondominant	Identical	97.8 (0.9)	95.1 (1.5)	82.9 (2.7)
	Unrelated	99.2 (0.6)	98.3 (1.0)	89.0 (1.8)
	Semantic	99.6 (0.4)	98.7 (0.7)	88.3 (2.3)

See the footnote to Table 1 for an explanation of the headings.

comparisons were conducted for significant effects at an alpha level of .05.

All three main effects were significant. First, the main effect of morphing was significant, $F_1(2, 38) = 27.88$, $p < .001$, partial $\eta^2 = .60$, and $F_2(2, 10) = 33.96$, $p < .001$, partial $\eta^2 = .87$. All three levels differed significantly for the participant and item means with shortest RTs for the 80%20% figures, followed by the 70%30% figures, and the longest RTs were observed for the 60%40% figures. Furthermore, the main effect of dominance was also significant, $F_1(1, 19) = 52.44$, $p < .001$, partial $\eta^2 = .73$, and $F_2(1, 5) = 24.94$, $p < .01$, partial $\eta^2 = .83$. When distractor words were related to the dominant object of the morphed figure, RTs were shorter than when distractor words were related to the nondominant object for both the participant and the item means. The main effect of relation was also significant, $F_1(2, 38) = 30.72$, $p < .001$, partial $\eta^2 = .62$, and $F_2(2, 10) = 15.79$, $p < .01$, partial $\eta^2 = .76$. For both types of means, the RTs for the identical conditions were shorter than the RTs for the unrelated and semantically related conditions. In addition, the RTs for the semantically related condition were significantly longer than the RTs for the unrelated condition for the participant means, but not for the item means. The interaction between morphing and dominance was not significant, $F_1(2, 38) = 1.68$, $p = .20$, partial $\eta^2 = .08$, and $F_2(2, 10) = 2.53$, $p = .13$, partial $\eta^2 = .34$. The absence of a significant effect indicates that the increase in RT observed for higher morphing levels was not different for distractor words related to the dominant or nondominant object of a morphed figure. The interaction between morphing and relation was significant for the participant means, $F_1(4, 76) = 2.79$, $p < .05$, partial $\eta^2 = .13$, but not for the item means, $F_2(4, 20) = 2.25$, $p = .10$, partial $\eta^2 = .31$. For the 80%20% and 70%30% levels of morphing, the RTs were shortest for the identical condition and longest for the semantically related condition, whereas for the 60%40% morphing level the shortest RTs were found for the unrelated condition.

TABLE 8
Mean percentage dominant responses and their standard error of the mean in brackets (also expressed in percentages) across items for all conditions in Experiment 2

		Morphing		
Dominance	*Relation*	*80%20%*	*70%30%*	*60%40%*
Dominant	Identical	99.2 (0.9)	97.8 (1.5)	95.5 (1.6)
	Unrelated	98.3 (0.9)	97.8 (1.3)	95.8 (2.7)
	Semantic	99.1 (0.9)	95.2 (3.2)	91.3 (3.7)
Nondominant	Identical	97.8 (1.3)	95.0 (2.1)	82.5 (4.0)
	Unrelated	99.2 (0.5)	98.1 (1.4)	89.1 (4.6)
	Semantic	99.6 (0.4)	98.6 (1.4)	88.4 (5.0)

See the footnote to Table 1 for an explanation of the headings.

The interaction between dominance and relation was also significant, $F_1(2, 38) = 45.03$, $p < .001$, partial $\eta^2 = .70$, and $F_2(2, 10) = 22.81$, $p < .001$, partial $\eta^2 = .82$. Post hoc comparisons revealed a difference in pattern between the dominant and nondominant condition. For the dominant condition, the participant means showed that the shortest RTs were observed in the identical condition and the longest RTs in the semantically related condition, a pattern similar to the main effect of relation. The item means showed a similar pattern, but probably due to the small degrees of freedom, the semantically and unrelated distractor words did no longer differ. For the nondominant condition, the participant means showed a significant difference indicating longer RTs in the identical and semantically related conditions in comparison to the unrelated condition ($p < .001$ and $p < .05$, respectively), and the item means showed a marginal difference ($p = .04$ and $p = .05$, respectively). This means that naming was slowed down by identical and semantically related words related to the nondominant object. The three-way interaction morphing, dominance, and relation was not significant, $F_1(4, 76) = 1.22$, $p = .31$, partial $\eta^2 = .06$, and $F_2(4, 20) = 0.47$, $p > .05$, partial $\eta^2 = .09$. The interaction effect found for dominance and relation, therefore, did not differ for the different levels of morphing.

In addition, error analyses were performed using the same within-subject variables as in the reaction time analyses. First, the main effect of morphing was significant, $F_1(2, 38) = 70.49$, $p < .001$, partial $\eta^2 = .79$, and $F_2(2, 10) = 9.88$, $p < .01$, partial $\eta^2 = .66$. All three morphing levels differed significantly for the participant means with most dominant responses for the 80%20% figures and least dominant responses for the 60% 40% figures, whereas for the item means only the 70%30% and 60%40% morphing level differed from one another, with more dominant responses for the 70%30% level. The main effect of dominance was also significant, $F_1(1, 19) = 12.29$, $p < .01$, partial $\eta^2 = .39$, and $F_2(1, 5) = 12.69$, $p < .05$, partial $\eta^2 = .72$, with more dominant responses to the targets superimposed by a distractor word related to the dominant object than to the nondominant object. The main effect of relation was not significant, $F_1(2, 38) = 2.90$, $p = .07$, partial $\eta^2 = .13$, and $F_2(2, 10) = 2.65$, $p = .12$, partial $\eta^2 = .35$. The interaction effect of morphing and dominance was significant, $F_1(2, 38) = 16.99$, $p < .001$, partial $\eta^2 = .47$, and $F_2(2, 10) = 9.84$, $p < .01$, partial $\eta^2 = .66$. The proportion of dominant and nondominant responses only differed for the 60%40% level, with more dominant responses for dominant than nondominant distractor words. The interaction effect of morphing and relation was not significant, $F_1(4, 76) = 1.14$, $p = .35$, partial $\eta^2 = .06$, and $F_2(4, 20) = 0.73$, $p > .05$, partial $\eta^2 = .13$. The interaction effect of dominance and relation was significant, $F_1(2, 38) = 9.62$, $p < .001$, partial $\eta^2 = .34$, and $F_2(2, 10) = 8.14$, $p < .01$, partial $\eta^2 = .62$. For the dominant distractor words, it was found that the proportion of dominant responses was lower for the semantically related distractor words than for the identical distractor words, though this difference was only observed for the participant means and not for the item means. For the nondominant distractor words, it was found that the proportion of dominant responses was lower for the identical distractor words than for the semantically related words. The three-way interaction effect of morphing, dominance, and relation was not significant, $F_1(4, 76) = 1.22$, $p = .31$, partial $\eta^2 = .06$, and $F_2(4, 20) = 1.72$, $p = .19$, partial $\eta^2 = .26$.

Discussion

In this experiment, a picture–word interference task was conducted in which all distractor words were part of the response set in order to control for possible response set effects. The results were similar to the results observed in Experiment 1, except for the interaction between dominance and relation. This means that, also for Experiment 2, dominant identical words induced facilitation, whereas the dominant semantically related words induced interference of the naming process. However, the distractor words related to the nondominant object yielded results that differed from those obtained in Experiment 1. In Experiment 1, the RTs of the nondominant semantically related words did not differ from the unrelated condition. In Experiment 2, however, they induced interference in relation to unrelated words. Clearly, inclusion in the response set indeed increased the likelihood of finding semantic interference, as was already suggested by Roelofs (2001). This difference in results between the two experiments is discussed further in the General Discussion.

GENERAL DISCUSSION

The aim of the current study was to investigate to what extent response candidates are activated during visual object categorisation. The prime question was whether (alternative) response candidates get activated not only up to a perceptual level but also up to a semantic level. With the former, we mean that only visual information is available and competition between response candidates takes place on basis of their perceptual similarity to the visual input. With the latter, we mean that aside from visual information also semantic information becomes available, such as category membership (i.e., semantic-category or semantic-coordinate), and competition is reduced or enhanced by the semantic information evoked by the related distractor word. Importantly, category information about the alternative responses might yield an effect during the activation stage of response candidates. To enhance activation of multiple response candidates, morphed figures were used as stimulus materials; because each morphed figure contains information of two objects, it was assumed that both objects were considered as response candidates (see also Daelli et al., 2010; Hartendorp, Van der Stigchel, Wagemans, Klugkist, & Postma, 2012). We conducted two picture–word interference experiments to investigate whether repetitive (dog-dog) and semantic context (cow-dog) interfered with the processing of a morphed figure. Participants were asked to name a morphed figure and to ignore the superimposed distractor word. The word was related to either the dominant or the nondominant object of a morphed figure. This relation between morphed figure and distractor word was identical, semantically related or unrelated. In Experiment 1, the semantically related and unrelated words were not part of the response set. In Experiment 2, the effects of response set membership were examined by using only distractor words that were all part of the response set.

In Experiments 1 and 2, the distractor words related to the *dominant* object affected the response latencies similarly as has been reported previously by other picture–word interference studies that used predominantly clearly identifiable pictures (Glaser & Düngelhoff, 1984; Sailor et al., 2009). On the one hand, the naming of a morphed figure as its dominant object was facilitated by a distractor word that was identical to the dominant object of a morphed figure, and on the other hand, the naming was slowed down by a distractor word that was semantically related to the dominant object. This is in line with the general finding from picture–word interference studies that the naming process is facilitated by identical words (dog-dog) and disturbed by semantically related words (cow-dog) (but see also Mahon et al., 2007).

Furthermore, in Experiment 1, we found that distractor words related to the *nondominant* object also interfered with the naming of a morphed figure as its dominant object, but only when a distractor word was identical to the nondominant object, and not when it was semantically related to the nondominant object. These findings support the idea that the activation of alternative response candidates can be increased by repetitive context causing more response competition between the preferred and alternative response candidates. However, the absence of an effect by the semantically related nondominant distractor words indicates that the response competition is not influenced by the semantic context. In other words, these results suggest that all response candidates, including the alternative ones, are represented at a perceptual level but not yet at a semantic level.

Caution is warranted regarding the foregoing conclusion. One might argue that the absence of semantic interference for nondominant distractor words may be due to response set membership. In Experiment 1, identical words were always members of the response set, whereas the semantically related and unrelated words were not. Roelofs (2001; see also La Heij, 1988; Levelt et al., 1999; Roelofs, 1992; but see Caramazza & Costa (2000, 2001), who found semantic interference when the response set did not contain all distractor words), for instance, showed that semantic interference was only found when the response set was small and repeated over trials. This way, the response set and its related lexical nodes were kept active in short-term memory. Hence, interference might be induced by nondominant semantically related words if they are members of the response set. In Experiment 2, therefore, the semantically related words were made part of the response set. We now found that the nondominant semantically related words indeed interfered with the naming process. In contrast to the conclusion of Experiment 1, the results of Experiment 2 thus would indicate that the nondominant object can be processed up to a semantic level.

How can we explain the different outcomes regarding semantic interference between the two experiments? We think the difference in short-term memory load between the two experiments is likely to have played an important role. In Experiment 2, the lexical nodes corresponding to the distractor words were probably activated due to the small and repeated response set (i.e., 16 distractor words). Moreover, an association between morph series and their semantically related words due to copresentation may have increased the activation of the lexical nodes of the words even more when they were functioning as semantically related distractors, which might have caused the small, but significant effect observed in the nondominant semantic condition. The current findings suggest that response set membership is a criterion for observing semantic interference. However, the difference in results between Experiment 1 and 2 cannot fully be ascribed to the difference in response set membership, because we also obtained semantic interference when the distractor words were not part of the response set (in Experiment 1 in the dominant semantic condition). In addition, others have also found semantic interference when the response set did not contain all distractor words (Caramazza & Costa, 2000, 2001). Moreover, the semantic interference effect observed in the nondominant condition was a weak effect and only reported under restricted conditions. Taken altogether, we therefore argue that the nondominant object is only processed up to the perceptual level.

Theories on lexical access differ in the locus of semantic interference. As discussed in the introduction to this paper, the locus could be at a lexical level (Bloem & La Heij, 2003; Bloem et al., 2004; Levelt et al., 1999; Roelofs, 1992; Starreveld

& La Heij, 1996) or at a postlexical level (Mahon et al., 2007). The conceptual selection model (CSM) by Bloem and colleagues (2004) seems most in accordance with the present findings. It is also the only account that incorporates competition between response candidates. In their model, the picture and word are first represented at a conceptual level. Only the selected concepts will reach the next stage, the lexical level. At this level, spreading activation occurs, causing interference when the distractor word is semantically related to the picture. Applying this model to the present findings, competition between the dominant and nondominant object of a morphed figure takes place based on perceptual information, leading to one preferred response candidate (in most cases, the dominant object). Subsequently, this concept will be processed up to the next level(s) where semantic information plays a part. This is supported by the interference effect induced by distractor words semantically related to the dominant object. In contrast, the nondominant object does not automatically reach this level. It only occurs under restricted paradigm conditions in which all distractor words are also members of a small response set.

Furthermore, it was observed that the level of morphing also influenced the naming process. Clearly, the more information a figure contained regarding the nondominant object, the longer the response latencies were. This suggests that the response competition between the dominant and nondominant response candidate was enhanced with increased morphing level, assuming that longer latencies indicate more response competition. Alternatively, one might argue that it is the increase in uncertainty causing the longer response latencies instead of the enhancement of the activation of the nondominant response candidate. Uncertainty, in this case, refers to having difficulties recognising any object in the visual input. However, we should note that there was a considerable increase in the number of nondominant responses for the higher morphing levels. If it had been just overall uncertainty, we would have expected an overall increase of alternative responses and not specifically an increase of nondominant responses.

In summary, semantic information related to the preferred response candidate (i.e., dominant object of a morphed figure) interfered with the naming process, whereas semantic information related to the alternative response candidate (i.e., nondominant object of a morphed figure) only influenced response latencies in some situations. We conclude that semantic information is probably not activated during the response competition stage, but only begins to play a role once a response candidate has been selected. This idea is in accordance with Bar's explanation of object recognition. Bar (2003) proposed that semantic knowledge is added to a concept only at a postrecognition stage. Moreover, object identification has been suggested to be an unfolding process (Yee, Huffstetler, & Thompson-Schill, 2011) in which the perceptual features are processed first and during a later stage the abstract features (i.e., the function of an object, or in our words, semantic information) are processed. Our results subscribe to this generally held tenet. Further research should reveal whether other types of information, such as associative information and parts-of information related to the nondominant object, might interfere with the naming process of morphed figures to understand more about the process underlying object recognition.

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APPENDIX A

The distractor words used in Experiment 1

		Dutch distractor words			*Translation distractor words*		
Morph series	*Object*	*Identical*	*Semantic*	*Unrelated*	*Identical*	*Semantic*	*Unrelated*
Airplane-Crocodile	Airplane	vliegtuig	bus	ring	airplane	bus	ring
	Crocodile	krokodil	slang	magneet	crocodile	snake	magnet
Arm-Banana	Arm	arm	voet	krant	arm	foot	newspaper
	Banana	banaan	mango	tafel	banana	mango	table
Bear-Bow	Bear	beer	tijger	deur	bear	tiger	door
	Bow	strik	stropdas	speen	bow	tie	teat
Car-Turtle	Car	auto	trein	koffer	car	train	suitcase
	Turtle	schildpad	kikker	hamer	turtle	frog	hammer
Church-Duck	Church	kerk	paleis	potlood	church	palace	pencil
	Duck	eend	bij	trui	duck	bee	sweater
Guitar-Sea Lion	Guitar	gitaar	trompet	bal	guitar	trumpet	ball
	Sea Lion	zeeleeuw	pinguïn	telefoon	sea lion	penguin	telephone
Gun-Rabbit	Gun	pistool	zwaard	sleutel	gun	sword	key
	Rabbit	konijn	hond	zwembad	rabbit	dog	swimming pool
Peacock-Truck	Peacock	pauw	hert	bed	peacock	deer	bed
	Truck	vrachtwagen	zeilboot	lepel	truck	sailboat	spoon
Pram-Squirrel	Pram	kinderwagen	draagzak	bloem	pram	carrier	flower
	Squirrel	eekhoorn	wolf	ei	squirrel	wolf	egg

The first column represents the names of the morph series, the second column represents one of two objects of the morphed figures in that particular morph series, the third column represents the identical words for the object in that particular row, the fourth column represents the semantically related words for the object in that particular row, and the fifth column represents the unrelated words. The 18 unrelated words were combined on every trial with another morphed figure of another morph series. Columns 6–8 contain the English translations of the Dutch distractor words.

APPENDIX B

The distractor words used in Experiment 2

		Dutch distractor words			*Translation distractor words*		
Morph series	*Object*	*Identical*	*Semantic*	*Unrelated*	*Identical*	*Semantic*	*Unrelated*
Car-Turtle	Car	auto	vrachtwagen	arm	car	truck	arm
	Turtle	schildpad	pauw	banaan	turtle	peacock	banana
Peacock-Truck	Peacock	pauw	schildpad	bel	peacock	turtle	bell
	Truck	vrachtwagen	auto	ketel	truck	car	kettle
Airplane-Crocodile	Airplane	vliegtuig	kinderwagen	appel	airplane	pram	apple
	Crocodile	krokodil	eekhoorn	hart	crocodile	squirrel	heart
Pram-Squirrel	Pram	kinderwagen	vliegtuig	lamp	pram	airplane	lamp
	Squirrel	eekhoorn	krokodil	man	squirrel	crocodile	man
Arm-Banana	Arm	arm	hart	vliegtuig	arm	heart	airplane
	Banana	banaan	appel	eekhoorn	banana	apple	squirrel
Apple-Heart	Apple	appel	banaan	kinderwagen	apple	banana	pram
	Heart	hart	arm	krokodil	heart	arm	crocodile
Bell-Kettle	Bell	bel	lamp	auto	bell	lamp	car
	Kettle	ketel	man	pauw	kettle	man	peacock
Lamp-Man	Lamp	lamp	bel	schildpad	lamp	bell	turtle
	Man	man	ketel	vrachtwagen	man	kettle	truck

Every object name functioned as identical, semantically related, and unrelated distractor word. Two morph series where object names were semantically related formed a pair (except for the last two morph series, these were included to balance the number of morph series).